AN INVESTIGATION OF PROCEDURES TO QUANTIFY TARGET DIFFICULTY IN PAIRED DISCRIMINATION TASKS

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Deborah S. Beard

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AN INVESTIGATION OF PROCEDURES TO QUANTIFY TARGET

DIFFICULTY IN PAIRED DISCRIMINATION TASKS

Approved:

Thomas L. Sadosky, Chairman

Russell G. Heikes

Leon F. McGinnis

Date Approved by Chairman 6/1/79

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SUMMARY

The investigation of shape perception has produced a variety of confusing, and sometimes conflicting, results. The variables in the literature which have been suggested to operationally determine shape detection and/or shape recognition responses are: area of the target, perimeter of the target, perimeter/area ratio, square of the perimeter/area ratio, length of the figure's longest side, number of inflection points in the figure, and maximum dimension of the figure (i.e. the length of the longest chord which can be constructed through the figure). In this study, all of the dimensions listed above were used as independent variables, except the maximum dimension variable. The variable "visual angle subtended" was used in place of maximum dimension because it is linearly related to maximum dimension and it is a more universal variable use for describing visual targets. Also, a new variable was introduced in this study which described the pattern similarity between pairs of shapes.

Subjects were given a choice reaction task in which they were first shown a slide of a "target" shape; then they were shown slides, consisting of pairs of shapes. One of the shapes was always the target. The other shape was designated the "distractor". The target could appear on either side of the screen and the subject's task was to press a button corresponding to the target's left/right orientation. Choice reaction time was measured for this task.

Prediction models were formulated using regression analysis. Choice reaction time was the dependent variable. The absolute values of the differences in the physical parameters (such as area, perimeter, and side length) of the target and the distractor were used as the levels of the independent variables. Shapes were grouped according to the general strategy of geometric shapes, symbol shapes, and nonsense shapes. Shapes of different groups were not cross-compared. Both group models and models for individual targets were derived.

The results indicated that group models were generally inferior to models for individual targets. However, pairs of targets which were constructed to be highly similar had models which contained the same set or a subset of the independent variables. All of the independent variables were used in at least one model, but pattern similarity and length of the longest side of the target were the variables used most often.

CHAPTER I

INTRODUCTION

A great deal of research has gone into the study of the effects of variables such as target size, illumination, size of the visual field and clutter on choice reaction time. Little research has been done, however, on the effects of target shape on choice reaction time. The experiments that have been conducted on target shape were frequently premised on theoretical models from Gestalt psychology or opthalmic physiology. The models proposed various psychological dimensions or physical properties of target shape to be predictors of the time required to respond to the shape of the target. The most frequently used predictor dimension is the ratio of the perimeter of the target to the target's area. However, the research to discover the relevant dimensions of target shape on reaction time have been quite contradictory, not only between experiments, but within experiments. For instance, in a study by Robert Sleight (1952), targets of different shapes were rank ordered by an averaged sorting time for a particular target shape from a large group of targets. In addition, several physical dimensions were measured or calculated for each target. None of the physical dimensions were consistent predictors of sorting time for a target shape, although for some of the variables the targets were ranked by sorting time in an order which corresponded to increasing (or decreasing) target dimensions.

In this study a variety of shapes were selected from the following stimulus groups: geometric shapes, nonsense shapes, coded symbols. Presentation of the stimuli was controlled so that factors extraneous to this experiment (such as stimulus illumination, background illumination, background illumination, size of the visual field, and location uncertainty) were set at constant levels well above the thresholds listed in <u>Human Engineering Guide to Equipment Design</u> for discrimination tasks.

From a human factors design point of view, studies os shape discrimination are gaining importance due to the increasing use of shape coding. Shape is frequently being used to code information for highway traffic direction and for international sign coding of directions and instructions. The need for information about shape detection arises in several industrial settings. One example of a shape detection task is the quality control inspection of products for flaws. The decision to keep or discard items is sometimes based on the shape of flaws which are distinguishable from the rest of the product. Another example occurs in realistic radar display screens where different aircraft are displayed as different shapes.

The purpose of this experiment was to determine what physical parameters of a target's shape are important as cues for recognition of the shape. Also, by grouping shapes together and trying to develop a prediction model for the group, it was hypothesized that underlying psychological or semantic cues might be discovered by studying the the variables used for the different group prediction models.

CHAPTER II

LITERATURE REVIEW

Although most researchers agree that the shape of an object will affect the time necessary to make a visual discrimination, no one can predict which shapes take longer to identify or why. Research which has been done in the field of shape detection or discrimination most frequently attempts to prove one of several popular theories concerning visual function. Seldom is research done in this field simply to quantify or order the ability to discriminate an object by its shape. For example, such research could provide a table of response times based on shape discrimination. The following is a review of the major studies conducted in the area of shape discrimination or detection.

General

Bitterman, Krauskopf, and Hochberg (1954) conducted an experiment where foveal thresholds for a variety of figures differing in form but equivalent in area were determined. Luminous figures were presented to dark adapted subjects at increasing, discrete levels of intensity until they could correctly name or describe the form. The figures used were a circle, square, equilateral triangle, L, cross, T, H, diamond and X.

Like many experimenters researching the area of form perception, Bitterman, et.al. postulate a diffusion model of form perception supported in the literature of Gestalt psychology. According to this theory, the circle should have a lower threshold than any other geometric form of equal area. This lower threshold is thought to be due to the fact that the circle has the smallest perimeter of any form; therefore, diffusion (of the chemical concentration in the visual cortex caused by transmission of the image on the retina) around the boundary of a circle will be less than diffusion resulting from perception of any other form. This theory has led to the belief that the ratio of the perimeter of a figure to its area could be used to predict perceptual thresholds for forms.

Bitterman et.al. used a Latin Square design to analyze the results of their experiment. According to the analysis of variance, variance due to order of presentation of the stimuli was insignificant; variability of the number of trials required for threshold (where each increment of illumination was considered a separate trial) was significant at the 5 percent level of confidence; variance due to form was "highly significant"; mean thresholds for each figure were plotted against the figure's perimeter to area ratio (P/A). The degree of relationship between mean threshold and P/A was expressed in terms of a rank-difference correlation coefficient. This coefficient (which was equal to .78) was significant beyond the 1 percent level of confidence. Therefore, according to this experiment, the parameter P/A is a good predictor of foveal form threshold.

Helson and Fehrer (1932) performed an experiment to determine whether or not form plays a decisive role in the determination of the lower threshold for illumination, the threshold for just noticeable form, and the threshold for certain form when illumination and form are the only aspects of the stimulus which are varied. Helson and Fehrer used six figures: isosceles, triangle, rectangle, circle, semicircle, angle, and square. In addition, each subject was dark-adapted, was using purely foveal fixation, and was provided with a red fixation light during stimulus presentation. Using the ascending series in the Method of Limits, the subject was allowed to turn a control knob, increasing the intensity of light until he or she could report the Light Limen (just noticeable light), Form I (just noticeable form) and Form II (certain form). The results indicated that there was no contribution to light limens from form, i.e., form is not a determining factor in the extremes of detection. For the Form I and Form II thresholds, the role of form is still confusing and contradictory. Depending on the response criteria used, different forms showed different thresholds. For example: the form requiring the least amount of light was a rectangle; the form reported most often for the Form I limen was the triangle; the form confused the least number of times with any other was the rectangle; the form requiring the least number of re-exposures for 50 correct and certain reports was the rectangle. Furthermore, in contrast to popular Gestalt predictions of the time, the circle appeared to be neither good nor bad according to any threshold criteria.

In experiments related to the physiological basis of form perception, the experimental procedure usually involves the pre-knowledge of all the stimulus forms to be used. For instance, in the moving method the stimulus object is slowly and continuously moved through the periphery to the fixation point with subjects reporting verbally when they can fixate the object. In the stationary method the test object is briefly exposed (perhaps with the aid of a tachistoscope) for different durations and at different displacements from the point of fixation. Again, the subjects usually give a verbal report concerning fixation of the stimulus. An outstanding criticism of this type of technique, as Day (1957) points out, is the effect of stimulus familiarity. Subjects need only a "stimulus-pattern" sufficient to suggest a certain form rather than the total spectrum of cues really needed for stimulus identification. Keeping this criticism in mind, Day set up his own experiment to prove the predictions of his theory on the physiological basis of form perception. Day presented the six forms shown in Figure 2-1. Subjects were not given prior knowledge of the stimuli to be used; they were required to describe and draw what they saw when the stimuli were exposed at set time intervals and angles of presentation. Day's results supported his hypotheses; in the outer periphery the figures were seen as dark almost formless patches on a whitish ground; closer to the fovea small edge indentations were filled in and corners were rounded by blurring at the edges; also, in this area, white spaces were seen as continuous with the rest of the figure due to a filling-in effect. As the figure was brought toward the fovea, these tendencies were resolved and a sharp definition of the figure emerged.

Clearly, the angle of presentation of the stimulus on the retina will affect form discriminations. In addition, pre-knowledge of the stimulus set could affect form discrimination. Attneave (1956; 1957) has conducted rather unique experiments in the field of form perception in that he used paired-associate learning tasks rather than threshold determinations to identify response to form or pattern perception.

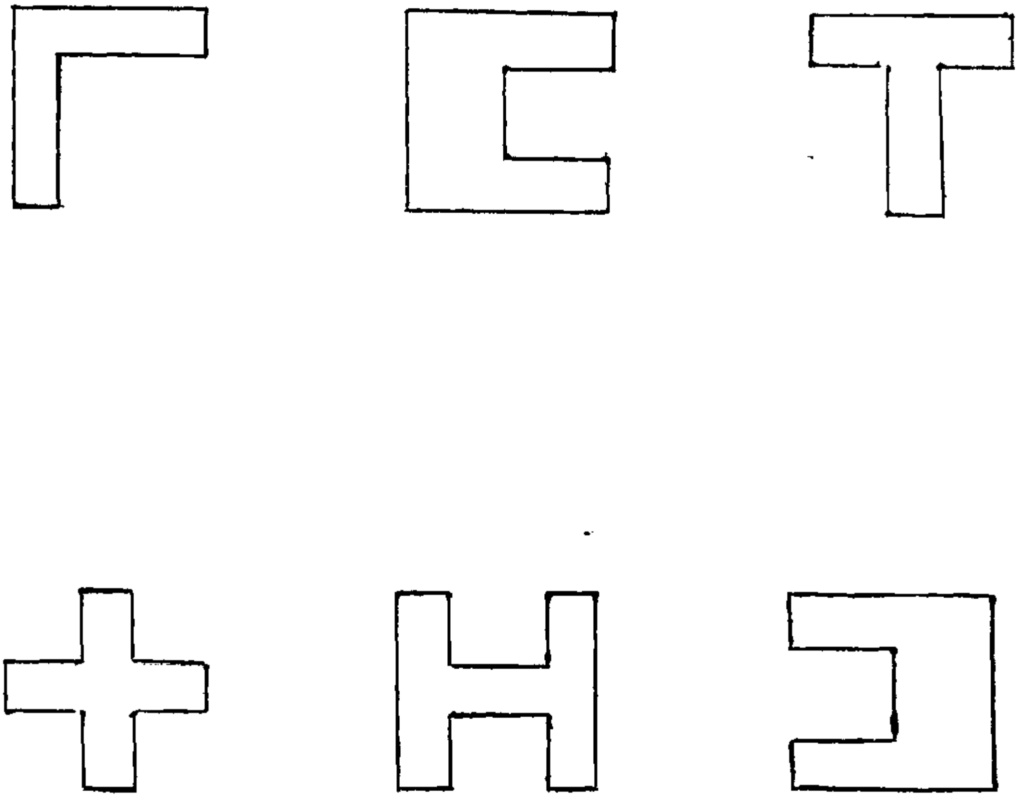


Figure 2-1. Examples of the Shapes Used in R.H. Day's Experiment.

Attneave's premise for the use of paired-associate learning in a study of form perception was that the learning of a classification system for sets of stimuli makes the subsequent learning of identifying responses to those stimuli easier. In other words if the subject in a form discrimination experiment has previously learned to sort many of the stimuli in the experiment into a distinctive class of objects, it may facilitate the onset, accuracy, etc. of the identifying response.

Attneave's subjects were assigned to one of two groups. The experimental group was given pretraining (consisting of reproducing the viewed figure) on a relevant prototype figure. The control group was given the same type of practice on a completely irrelevant figure. In the actual experiment, subjects were given one of eight variations on the prototype as a stimulus. Subjects were given six learning trials in which the stimuli were associated with a man's name (e.g., Sam or Joe); then the subject was given a learning trial in which one of the stimuli was presented and the subject was instructed to write the correct name of the stimulus. A t-test on the difference between the total errors of the experimental group versus the control group showed significance at the .01 level of confidence. Examples of a prototype and four of its variations used in the experiment is shown in Figure 2-2.

In a second, related experiment Attneave used essentially the same experimental design, but he used nonsense polygon shapes instead of letter patterns. He also introduced an additional variable which quantified the way in which the shapes differed from their prototype. This quantification was accomplished by picking a certain number of points in a constructed figure to be randomly relocated and setting an approximately constant distance of movement. The advantages of pretraining

```
1.      S KYG          2.      S KYG
       F YPYK                 F YPZK
       P  OF                  P  OF
       R I I                  R I I
        D   W                  D   P

3.      S KYG          4.      A KYG
       F YRZK                 F YPZK
       P  OF                  P  OF
       R I I                  R I I
        D   W                  D   W

  (Prototype)       S KYG
                   F YPZK
                   P  OF
                   R I I
                    D   W
```

Figure 2-2. Example of Prototype and Variations Used in Attneave's Study of Pattern Identification.

with a prototype figure were not as apparent in this experiment. Differences in the control and experimental groups were small, variable and, in certain comparisons, in the unexpected direction. Therefore, it appears that pretraining, or familiarity, has a definite influence upon the recognition of patterns and perhaps on well-defined shapes. However, pretraining does not have much, if any, effect upon responses related to random or nonsense shapes.

Casperson (1950) experimented with form discrimination for six geometric forms which were varied systematically along the quantifiable aspect of area, perimeter, and maximum dimension. He defined form discrimination as "the identification of a particular geometric form as being different from all other possible ones". The geometric forms used were ellipse, rectangle, triangle, diamond, cross, and star. As Casperson pointed out, empiricists predict that such familiar forms are easier to perceive or discriminate. However, most subjects are so accustomed to these particular forms that differential experience or learning effects should be fairly equal throughout the experimental population. It should be noted that in other experiments, using random forms or symbolic figures, this equality of experience can not be assumed.

In the Casperson study, each of the six geometric forms was constructed five times systematically increasing maximum dimension and perimeter while keeping the area of the figures constant. These thirty forms constituted one set of stimuli, all of equal area. Seven sets of stimuli (with thirty forms each) having systematically varying area or perimeter or maximum dimension were used. As one dimension was varied the other two were kept constant. It was impossible to construct forms which had exactly equal perimeter or maximum dimension along a continuum for different forms, but perimeters and dimensions agreed as closely as possible. An example of one set of figures used in the study is shown in Figure 2-3. The subject was instructed to judge a complete set of thirty figures and name each form in terms of the basic geometric shapes used. Each subject was exposed to a card containing all thirty forms, which he or she named off from left to right as rapidly as possible without sacrificing accuracy. The method of forced guesses was used. The percent of correct reports, corrected for empirically determined response probability, was used as the measure of discriminability. The results are summarized as follows:

1. Between-form variance was larger than average within-form variance; i.e., the differences between forms are real and are greater than the differences produced by variations in the construction of the stimuli.
2. For the elliptical and triangular forms, area was the determining factor in discrimination.
3. For the rectangular and diamond shaped forms, maximum dimension contributed most to discriminability.
4. For crosses and stars, perimeter was the best predictor of discriminability.
5. To predict the relative discriminability of the average shape for the six geometric forms used, maximum dimension is the most useful information.

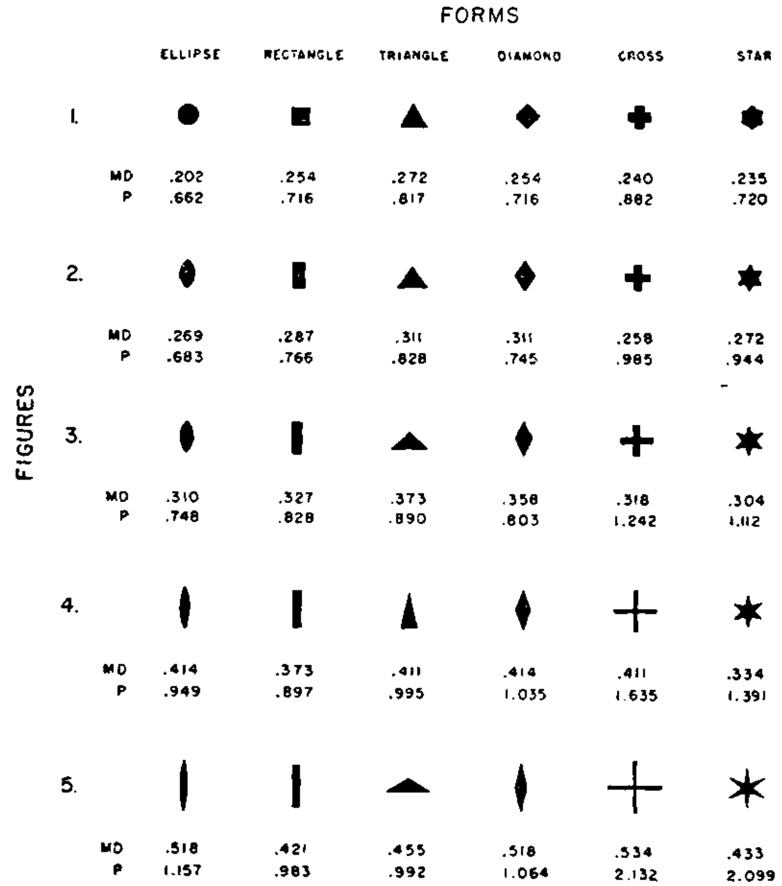


Figure 2-3. Examples of a Set of Shapes Used in Casperson's Study. The "forms" constitute the Basic Shapes Employed in the Study. The "figures" Result from Systematically Varying the Dimensions of Perimeter or Area or Maximum Dimension of the Forms.

6. To make all thirty figures (of equal area) equally discriminable, one should equate their perimeters. (Note that this is consistent with the diffusion theory of form discrimination).
7. The elliptical shapes (which contained one circle in each stimulus set) were not particularly easy to identify. They usually fell in the midrange of predictability according to any particular dimension. This does not support the Gestalt theory of "simplicity of form". Whereby the circle (hypothesized to be the simplest form) should be the most identifiable form.
8. Variance contributed by the twenty subjects in this experiment was small compared to the variance due to differences in form.

In a study related to military applications of form discrimination for use in shape coding; (Smith and Thomas; 1964) shape coding and color coding were compared to determine their respective contribution to discrimination of targets. Although the color coding aspect of this experiment is of no interest here, the experimental trials in which color was held constant and shape was varied are of some interest. The usefulness of the information from this study is due to the fact that they used sets of military symbols and aircraft shapes in addition to geometric forms. (See Figure 2-4 for a description of targets). The aircraft shapes were purported to represent a fairly difficult set for shape discrimination; the geometric forms were triangle, diamond, semicircle, circle and star and no hypothesis was stated about their relative discriminability; the military symbols were suggested to represent an easily discriminable set of forms. Subjects were shown a slide containing different display densities with targets randomly placed on a

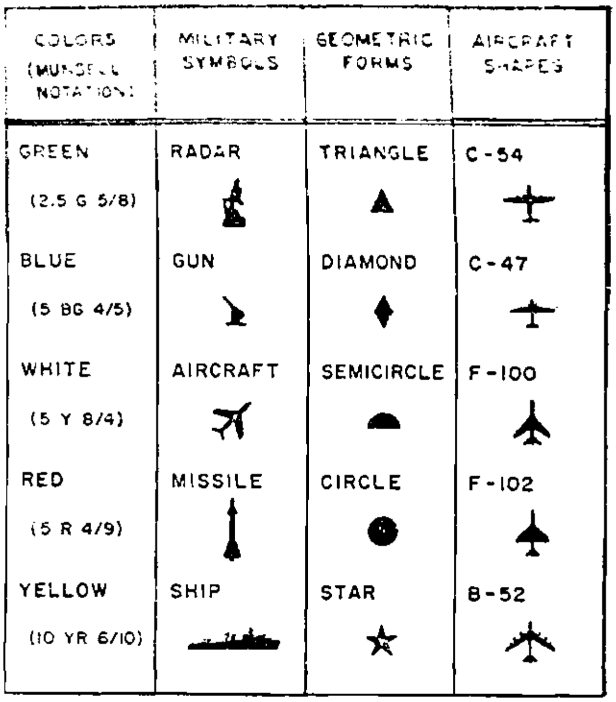


Figure 2-4. Three sets of Shapes Used in Smith's and Thomas Study of Shape and Color Coding.

grid containing 400 possible matrix locations. In the experiment regarding shape alone, S's were asked to count each display five times, once for every shape in the target set. Average counting times were plotted against each display density for each form in the set. Data analysis showed reliable differences (p .001) in both time for counting and errors in discrimination for the different forms within the military symbol set and the geometric form set. However, for aircraft shapes the differences were not as clearcut (p .01). This result indicates that the relevant dimensions necessary for discrimination are present to a lesser degree in the aircraft shape set; thus, measures of discriminability in a group of shapes highly similar in detail seem to be less variable in response to identifiable characteristics of the shape.

Robert Sleight (1952) pointed out different response criteria used in studying form discrimination and the general results associated with these criteria as a prologue to his experiment on relative discriminability of "geometric" forms. One of the response criteria used by several investigators is the extension of form field, i.e. the area on the retina where the projection of the stimulus object can be detected (or recognized). However, Sleight reports that no definitive statements can be made concerning this measure when different forms are employed. A second response criteria is accuracy of reports when forms are viewed at a distance. However, he reports that other investigations dealing with the visibility of distant targets find that there is no difference in the probability of detecting a variety of shapes when area of the targets is held constant. Another example of contradiction occurs in investigations using intensity thresholds for various forms. Using similar figures, two researchers were reported to disagree upon the ranking of the figures. Finally, Sleight says the several experimenters using accuracy of peripheral discrimination as a criterion agree on the relative discriminability of some forms but disagree on the rankings of other forms. The response variable that Sleight used in his study was sorting for a large group of figures, some of which were purely geometric forms and some of which were configurations given arbitrary names by the experimenter. Subjects were exposed to a board containing 126 figures. (Each figure was repeated six times in the set). Each figure was the maximum size which could be inscribed within a one inch circle in order to roughly equate apparent size. S's were usually given the choice of which figure they could sort first, but all six representations of the figure had to be sorted before proceeding to the next shape. The experimenter gave a start signal and the subject signalled when he was finished with each sort. Six separate trials involving sorting of all 126 figures were run and mean sorting times were computed for each figure. Figures were then rank ordered by mean sorting time. No real distinctions could be made between "discrimination time" for the figures based on some intrinsic qualities of the stimuli. However, it is noteworthy that the swastika had a mean sorting time ten times smaller than the sorting time for the "poorest" figure, the hexagon. Several possibilities for the justification of the differences in sorting times are possible: 1. The Swastika has significantly more angles than the hexagon. However, the swastika also has significantly more angles than a circle, whose mean sorting time is closest to that of the swastika. On the other hand, the cross and the star, which have the same number of angles, have essentially the same sorting time. 2. Similarly, the

ratio of perimeter to area is much larger for the swastika than a hexagon, but the ratio of perimeter to area between a circle (the second lowest sorting time) and a hexagon (the longest sorting time) are quite close.
3. All in all the ranking results for the different figures are very confusing in the light of other research in this field. One clue to a partial explanation of these results may be the fact that, when given a choice, subjects always chose the swastika to sort first. It is possible that swastikas (and certain other fitures) may be highly discriminable forms due to some prior learning experience rather than some physical characteristic of the stimulus.

Several experiments relevant to the topic here were reported in a symposium on form discrimination as it applied to military problems. (Form Discrimination as Related to Military Problems; 1957). For instance, Alfred B. Kristofferson reported on an experiment that he conducted in which the theory of spatial summation for the detection of a target was tested. The theory of spatial summation asserts that the "detection of a target occurs whenever the amount of excitation at any point in the neural excitation pattern produced by the target exceeds a critical value". As a result of this theory, two predictions can be made: 1. Target luminance required for threshold detection of a target will decrease as target size is increased; and 2. The shape which will maximize detectability is a circle because a circle possesses the maximum area (translated into maximal summation) for a given perimeter. Targets in this experiment were presented as increasing areas of luminance against a uniform luminous field with four fixation lights (the target appears in the middle of the lights). Contrast detection thresholds were determined by measuring the 50 percent detection probability at each of five luminous levels by the temporal forced-choice method. The response data was plotted as log threshold contrast on the ordinate axis versus log area on the abscissa. The targets were circles, rectangles, multiple leg figures, and geometrical forms.

The result of this experiment was that the spatial summation theory did not predict detection of targets as accurately as hoped for. This was especially true when long thin rectangles were used. These rectangles were much more detectable than predicted by the theory. Two aspects of target geometry which seemed best to correct for errors of prediction were: 1. The difference between the length and the width of the target; 2. The percent utilization of the area of a box which just encloses the target. In further experiments designed to account for the discrepancy produced by these rectangles, a relevant target dimension, 1', which represented the total linear extent of the object emerged. Interestingly, 1 x 64 rectangles did not differ from 1 x 64 crosses in detectability. It was suggested that the element contribution (spatial summation) theory might vary when elements were distributed along different meridians. To test this hypothesis, thresholds were determined for the 1 x 64 rectangles at a variety of linear orientations. The result was that orientation was of "minor importance". The rectangles were more detectable than the spatial summation theory predicts at any orientation.

A second experiment reported at the symposium was by Richard H. Henneman. (Form Discrimination as Related to Military Problems; 1957). Henneman conducted a simple experiment on the contribution of relevant and irrelevant information in the determination of complex discriminations. Subjects were presented with figures which varied along the following dimensions: 1. Circle or ellipse; 2. Large or small; 3. Number and kind of markings within the circle or ellipse; and 4. The shape and filling fo the border around the circle or ellipse. The first two dimensions were considered primary dimensions of the stimuli. The second two dimensions were considered secondary dimensions of the stimuli. The subject responded to presentation of the slides by making one of sixteen responses (pushing or pulling on one of eight response keys). In the Zero Irrelevant condition all dimensions (primary and secondary) were relevant to the response.

In the Never Relevant condition, two secondary stimulus dimensions that were never involved in the identification of the stimulus patterns were added. For example, in one instance the markings of the figure were relevant and the border around the figure was never relevant. The third experimental condition was the Sometimes Relevant condition. In any given stimulus pattern, one of the secondary dimensions of the figure was relevant and one was irrelevant. Relevant and Irrelevant dimensions were varied systematically throughout the group of stimulus patterns to be identified. As expected, response time decreased and accuracy improved over the number of trials. Also response times for The Never Relevant and Always Relevant conditions were about the same and were consistently lower than the response times for the Sometimes Relevant groups of stimuli. The results of this experiment simply indicate that the dimensions a subject uses to identify or discriminate a figure as well as the frequency of relevance for these dimensions could affect the response time. For instance, if a subject was given a group of targets to discriminate according to the number of sides in the figures or number of angles in the figure such as a triangle, a quadrangle, a pentagon, a hexagon, etc. and then is presented with a group of figures (such as rectangle, trapezoid, and diamond) where orientation of the figure or variable angles in the figure is the identifying dimension, response times could be affected.

At the symposium on military application of form discrimination Benjamin W. White reported a study by James Deese of Johns Hopkins University in which more errors of identification were made in response to simple forms than to complex forms. (Form Discrimination as Related to Military Problems; 1957). White proposed to explain this unexpected result in terms of the heterogeneity and the homogeneity of the stimulus targets involved. White thought that Deese had neglected to control the heterogeneity of his figures and that the complex targets had happened to form a more heterogeneous (and thus more discriminable) set of stimuli than the simple targets. White constructed sets of targets controlled for two factors: simplicity/complexity and heterogeneity/homogeneity. The distinguishing factor for simple targets versus complex targets was that the complex targets had more angles. For the homogeneous sets of targets two cells in a matrix, upon which the prototype figure was superimposed, were varied to form four other targets. The heterogeneous set of targets varied by five cells from the prototype figure. S's were presented with a single form slide (prototype) from one slide projector with a 1/50 sec. exposure. Immediately after exposure of the first slide, a second slide projector displayed the slide containing the original figure and four variations on the original figure. In the multiple figure slide, each figure was labeled with a letter and subjects were to respond by calling out the letter of the matching figure. Percent of correct identifications was calculated for the four groups of targets: simple/homogeneous, simple/heterogeneous, complex/homogeneous, and complex/heterogeneous. The results of the experiment were as follows: 1. The homogeneous sets were significantly more difficult to identify than the heterogeneous sets. 2. In general, the complex figures were significantly more difficult to identify than the simple figures. 3. However, the significant difference between simple and complex figures did not hold up in the heterogeneous set of figures alone. One additional note provided by White is that "the method employed in this study...is most appropriate when all the forms are of equal area, when they are generated by introducing controlled variations on a single parent form, and when all the forms are presented in a single orientation."

The final report of interest from the symposium was by Wyatt R. Fox. Fox wanted to determine the effects of size, shape and edge-gradient on detection and recognition. He also wanted to know whether or not recognition thresholds could be predicted from detection thresholds. Fox points out that for detection, some researchers have theorized that the amount of area has the greatest effect on detection threshold. They predict that as area is increased, detection threshold will systematically decrease indepdent of the shape of the object. Other investigators believe that detection threshold is dependent upon the amount of edge or perimeter of an object, and thus its shape. Fox criticizes the area explanation of detection threshold, saying that thresholds do differ for stimuli equal in area but varying in shape. He criticizes the theory proposing a relationship between the changes in edge-gradient and the detection threshold by pointing out that lack of information leaves this hypothesis unproven. Like many other researchers, Fox notes that Gestalt theory, which predicts that threshold for recognition of form will increase as the ratio of perimeter to area increases (providing area is kept constant), has been proven inadequate many times by experimenters showing that swuares and triangles have often been proven more "recognizable" than circles. However, the circle should have the lowest recognition threshold because it has the lowest perimeter to area ratio.

Fox used the method of single stimuli to determine the brightness contrast thresholds for figures varying in perimeter-to-area ratio. He used the figures: circle, irregular shape, square, triangle, cross, and star. The figures were presented over three foveal sizes, and three edge gradient conditions. Edge gradients were constructed by photographing the different figures through several apertures placed in front of the camera lens. Subjects were dark adapted, and used monocular vision (with their dominant eye). Stimuli were presented in the center of four illuminated orientation dots. Multiple measures were taken on two subjects.

The findings of the experiment were:

1. Increasing the size of the stimulus decreases the threshold of detection at a decreasing rate.

2. The shape of the stimuli did not affect detection thresholds for the smallest targets, but for the larger sizes shape did affect the detection thresholds. The irregular shape and the cross had higher thresholds. (Significance was not reported).
3. Decreases in the steepness of the edge-gradient were directly related to increases in detection thresholds.
4. Increase in the stimulus size increased the frequency of correct responses for recognition.
5. The shape of the stimulus had a significant effect on recognition threshold. The irregular shape and the cross had higher recognition thresholds than the circle, square, triangle and star. Circles were rarely confused with other forms. None of the parameters such as area, perimeter and perimeter-to-area ratio could adequately predict recognition thresholds.
6. A decrease in the steepness of the edge-gradient systematically increased the threshold for recognition. Error responses did not increase appreciably with a decrease in steepness of edge-gradient. However, sugjects stopped responding to very blurred figures, except at the very brightest contrasts, rather than giving "guessing" responses.
7. As size of the stimulus increases, recognition thresholds regress at a negatively decreasing rate down to the detection threshold as a limit.
8. The recognition thresholds were raised slightly more by edge-gradient changes than the detection thresholds. (Significance

was not reported.)

9. The threshold rankings by shape were essentially the same for recognition criterion and detection criterion.

10. Familiarity of stimulus forms "seemed to affect both detection and recognition thresholds."

Since the present study is concerned with the use of response time (to discriminate between a target and a distractor and to press the appropriate key), Kaswan's and Young's experiment to determine the effects of luminance, exposure duration, and task complexity on reaction time might be of some interest. It would be helpful to subtract response time increments which relate to luminance, time of exposure, or time due to "mental processing" for the task from the total response time. Therefore, the findings from Kaswan's and Young's study might be of interest for comparison.

In one part of their study, Kaswan and Young had subjects decide which of two patterns they were being shown: and evenly spaced pattern of dots or a pattern of double dots, i.e. dots patterned in pairs. The experimenters used eight different exposure durations and eight luminances; they had subjects make a decision while presenting the patterns using the Method of Constant Stimuli. In the second part of the experiment, the experimenters used the same exposure durations and luminances and the same experimental method. The task was changed, however, so that the subjects were asked to press a single microswitch key when they saw the stimulus; this was simply a task of detecting figure against ground.

The results of the two experiments are listed below:

1. In the discrimination task, the shape of the curves for the

different dot patterns (paired dots and evenly spaced dots) at different separations looked about the same. Paired dot patterns were always discriminated faster than evenly spaced dot patterns. Decreasing separation of the dots or pairs increased reaction time.

2. RT for the pattern discrimination task seemed to be equally affected by the exposure duration as by the luminance of the light source. However, in the detection task, luminance affected RT to a greater extent than did exposure duration.
3. The curves relating exposure-duration and luminance to RT are distinctly different for the different tasks. This implies that the effects the physical parameters of the stimulus have on RT are related to the nature of the task involved.

Summary

To date, there has been no quantifiable variable or group of variables which has been reliably demonstrated to be a predictor of choice reaction time for shape of a figure. The literature specific to this topic is often contradictory. Many variables related to the physical characteristics of a figure have emerged in these studies as partially successful predictors of the relative discriminability of different figures. Such variables are: area, perimeter, the ratio of perimeter to area, the square of the perimeter/area ratio, maximum dimension of the figure, number of angles, length of the longest side, percent utilization of a box which just encloses the figure, and angular orientation of the figure. However, no researcher has as yet systematically studied the effect of all of these variables or all of the possible combinations of these variables on choice reaction time for shape of a figure. Table 2-1 presents a summary of the literature on the study of shape perception.

The variety of figures used in different experiments involving shape discrimination has included: simple geometric shapes, variations of block letters and shapes, aircraft symbols, "nonsense polygons", dot patterns, military symbols, symbols which presumably had some psychosocial meaning in the population tested (such as a swastika or heart shape) and complex geometric shapes. The only experiment which classified the shapes employed into target groups and tested each group independently was the study by Smith and Thomas (1964). Smith and Thomas used two separate groups of symbols postulated to have different degrees of intra-group similarity (and thus different difficulty of discrimination) and one group containing geometric shapes of varying complexity. Most of the studies reported mixed shapes, which could be classified into distinct categories, within an experimental paradigm.

A variety of response criteria have been used in the study of shape discrimination or identification. Most often sorting or matching tasks are used in discrimination studies. Identification studies frequently use paradigms for establishing psychophysical thresholds. None of the studies cited in the literature review used choice reaction time as a response criterion.

In a chapter reviewing the literature on visual form perception, Graham (1965) states that the "reader may gain the impression that the field of form perception consists of relatively disjointed areas rather

Table 2-1. Summary of the Results Presented in the Literature on Shape Perception

Authors	Year	Paradigm	Shapes Used	Results
1. Bitterman Kauskoof Hochberg	1954	Psychophysical- luminous figures were presented foveally to dark-adapted subjects at discrete levels of intensity until identification threshold was reached (i.e., named figure)	Circle Square Equilateral Triangle L Cross T H Diamond X	1. Number of trials to reach threshold differed by target shape (.05 level). 2. Mean threshold was plotted against figure's P/A; the degree of relationship was expressed as a rank-difference correlation coefficient (.78) significant at .01 level. This implies that P/A is a good predictor.
2. Helson Fehrer	1932	Psychophysical- threshold for just noticeable form when illumination and form were varied	Isocecles Triangle Rectangle Circle Semicircle Angle (L-shape) Square	Form not a factor in detection of a figure; results were contradictory for discrimination.
3. Day	1957	The subjects had no prior knowledge of shapes. Subjects described and drew figures when time of presentation, angle of presentation, and position of the target on the retina were varied.	Inverted L-shape C-shape T-shape Cross H-Shape backward C-shape	Presentation of form on the fovea affected the discrimination of targets of different shape.

Table 2-1. (Continued)

Authors	Year	Paradigm	Shapes Used	Results
4. Attneave	1957	Paired associate learning tasks (rationale: if the subject has learned to sort stimuli into classes, it may facilitate the onset and the accuracy of the identifying response) Two groups were tested: one had pretraining on relevant figures; the second had pretraining on irrelevant figures. Subjects trained on all stimuli for six trials; then they identified 1 figure on the 7th trial.	Letter patterns prototype and variations nonsense polygons: prototype and variations	For letter patterns and the difference in relevance of pretraining figures was significant (.01 level); errors were the response criterion. For nonsense shapes: there was no difference in pretraining groups i.e., pretraining (a familiarity) has effects for responses to well-defined shapes only.
5. Casperson	1950	Varied area, perimeter, maximum dimension. Subjects were exposed to 1 of 7 sets of forms. Varying in perimeter, area and maximum dimension. Subjects had to name forms from left to right. Forced guesses were used.	Ellipse Rectangle Triangle Diamond Cross Star	Between form variances greater than within form variance (% correct reports was the response criterion). For elliptical and triangular forms area determined discriminability. For rectangle and diamond shapes maximum dimension determined discriminability.

Table 2-1. (Continued)

Authors	Year	Paradigm	Shapes Used	Results
				For cross and star shapes perimeter determined discriminability variance due to subjects was small compared to variance due to form. Both variance for form (^{2}=263, 939.02) and variance for subjects (^{2}= 417,46.15) were significant at the .01 level. Subject variance was stated to be small compared to form variance.
6. Smith Thomas	1964	Subjects were shown slides of different display densities with randomly placed targets; the subject counted the display once for each type of target in the display. Average counting times was the response criterion.	Military symbols Aircraft shapes Geometric forms.	There were significant differences in counting time and errors for form in military symbol set and the geometric set (p. .001). For aircraft shapes differences between forms were significant at the p - .01 level.

Table 2-1. (Continued)

Authors	Year	Paradigm	Shapes Used	Results
7. Sleight	1952	Sorting large group of figures on a board.	Simple geometric shapes complex geometric shapes symbols	Sorting times rank ordered results do not reveal any relevant shape characteristics.
8. Kristofferson	1957	This was psychophysical paradigm with forced choices, to find detection thresholds.	Circles rectangles multiple leg figures geometrics	The spatial summation theory was disproved. Maximum dimension and the percentage of the area of a box just enclosing the target proved to be good correction factors.
9. Henneman	1957	Figures were varied in shape, size, border of field, and markings within the figure. The subject was given combinations of relevant and irrelevant stimulus dimension; the response criterion was time to push one of eight response keys.	Circles Ellipses	The dimensions a subject used to discriminate figures as well as the frequency of relevance for these dimensions affect response times.
10.White	1957	Controlled target simplicity/complexity and homogenity/heterogenity. The	Nonsense shapes	Homogeneous sets were more difficult to identify. Complex figures were more

Table 2-1. (Concluded)

Authors	Year	Paradigm	Shapes Used	Results
		response was to match one figure in a group to the original figure on displayed on a separate slide. The percentage of correct identifications was the response used.		difficult to identify in homogeneous targets.
11. Fox	1957	The psychophysical method of single stimuli was used to find the brightness contrast threshold for figures varying in P/A.	Circles Irregular shapes Squares triangles Crosses Stars	Findings of interest: the shape of the stimulus had a significant effect on recognition thresholds; but A, P or P/A were not good predictors of recognition threshold. The threshold for shape identification was the same for recognition as for detection.

than firmly joined segments. In view of this aspect that the field presents, one tends to regard hopefully and with more than passing interest any attempt to establish a general method for studying for perception."

CHAPTER III

METHODS AND PROCEDURES

Targets

For the purposes of this experiment, it was postulated that there exist some non-measurable shape variables which may be roughly defined as symbolic meaning and/or stimulus familiarity for the population to be tested. To attempt to account for these aspects of shape without assigning arbitrary semantic or quantitative values to them, three distinct target groupings were used: 1. Basic geometric shapes; 2. Symbols; and 3. Nonsense shapes. The hypothesis was that by comparing each of the three types of targets only to other targets in their group, a regression model could be developed for each group of targets. These models could then be examined to determine if different variables were used to develop the models for different types of targets. Also "goodness-of-fit" measures could be compared for each of the models to determine whether there is a significant difference in the models' ability to predict choice reaction time. Finally, average choice reaction time could be compared between the three groups. It is hypothesized that the longest choice reaction times will occur between discriminations for nonsense shapes because of the lack of familiar cues for discrimination. The shortest choice reaction times should occur for the trials using symbol shapes; not only do these shapes have familiar cues for discrimination, they have semantic meaning in that they can be easily named or identified. The average choice reaction time for geometric shapes should fall somewhere near that of the symbols; again this would be due to familiarity and, to a lesser degree meaning.

The actual targets within each group were chosen or constructed with several criteria in mind. One factor was to create paired discriminations with varying degrees of difficulty. Therefore, each target had a corresponding figure in its group which was constructed to shtat the two figures were as similar as possible. For instance, in the geometric group, the trapezoid was constructed so that it was one-fourth inch wider at the apex than the triangle; the width of the rectangle was one-fourth inch less than that of the square. Another factor which influenced the choice of target shapes was variety of the basic construction of the figure. Therefore, targets were chosen so that each group had two curvilinear shapes, two angular shapes with acute angles, and two block-types shapes which were somewhat regular and contained only right angles (see Figures A-1 through A-18 in Appendix A). One or both of these constraints was satisfied whenever feasible.

All of the figures were constructed to be of maximal size within a three inch square. In general, the geometric shapes were constructed so that corresponding pairs of figures varied by one-fourth inch along one dimension. Symbol shapes were also constructed to minimize differences between corresponding pairs. For example, the radius of curvature is the same for the crescent and the right turn arrow; the arms of the cross and the X have the same width. The nonsense shapes were constructed by picking a random number of points on a grid and connecting them using curvilinear segments for one figure, lines joined at acute angles for another figure and lines joined at right angles for the third figure. To construct a corresponding figure of high similarity, a random selection of several of the basic inflection points were moved around a one-fourth inch radius.

All of the targets were made of heavy, white matte paper. They were photographed against a black background; the negatives were then made into slides, so that the result was a series of black targets on a white background. The slides were projected on a rear projection screen to display images twice the size of the original figures. The subjects viewing distance was 72 inches.

Experimental Procedure and Experimental Design

The experiment consisted of three groups or categories, of shapes with six figures per group. The following is a list of the names of the figures by group (see Appendix for further detail):

1. Geometric Shapes
    a. circle
    b. ellipse
    c. triangle
    d. trapezoid
    e. square
    f. rectangle
2. Symbol Shapes
    a. right turn arrow
    b. crescent
    c. cross

d. X

e. E

f. F

3. Nonsense Shapes

a. curve I

b. curve II

c. angle I

d. angle II

e. block I

f. block II

Each subject was shown eighteen sets of slides, one set for each figure. At the start of a set a slide containing a single shape was displayed. This figure was designated the target shape (hereafter referred to as the target). The remainder of the slides in the set contained pairs of shapes. One of these shapes was always the target. The other shape in the slide was either one of the other shapes from the target's group or a picture of the target itself rotated 45° counterclockwise or 90° counterclockwise; this figure will be referred to as the "distractor". The subjects were instructed to choose the figure which was a match for the target in both shape and angular orientation. Targets were never compared to shapes from other groups of figures. Each target was presented with every other shape in its group and with its rotated version, twice per set; once the target appeared on the right side of the slide and once the target would be displayed on the left. The subject was instructed to push one of two buttons on a black box. He pushed the right button if the target appeared on the right side of the screen, the left button if the target was on the left.

Since the experimental task proved to be somewhat monotonous on several test runs, all subjects were offered the opportunity to take a five minute break after 30 minutes. There were no specific incentives provided for participation in this experiment.

The total number of slides viewed by each subject was 244. It should be noted that some of the targets were not paired with a distractor of the same shape but different angular orientation because the resulting pair would not be discriminable; for instance, the circle was never rotated and paired with itself; the square was not rotated 90° and paired with itself. All subjects viewed all permissable combinations of the target and distractor pairs.

The slides were randomized within sets by assigning each slide in the set a number and using a random number table to determine the order of presentation. These sets were then assigned a number and again they were randomly assigned an order within eight slide carousels. For each subject carousels one through eight were presented in a random order according to a series derived from a random number table. This methodology allowed a partially constrained random presentation of sets of slides, however, because the order of the slides within the carousels remained the same from subject to subject.

The subjects were given the sheet of instructions shown in Figure 3-1 and told to read them. After several minutes the experimenter read the instructions aloud and asked if there were any questions. The subjects were cautioned that accuracy was important in this experiment so they were not to make guesses. The subject was asked to inform the experimenter whenever possible if he detected a mistake after pressing a button.

Subjects viewed the slides with binocular vision in a room with dim ambient lighting. Subjects were given time to let their eyes adjust to any gradient between overhead room lighting and the illumination level used for viewing the slides. Illumination of the targets and size of the targets was well above threshold.

Subjects

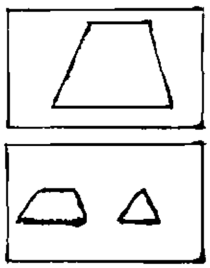
The population for this experiment consisted of fifteen subjects, four of whom were females and eleven were males. Subjects were either college students or college professors with an approximate age range of 18 to 45. All the subjects had 20/20 or 20/20 corrected vision. The time required to view and respond to all of the slide pairs was approximately one hour per subject.

INSTRUCTIONS

This experiment is designed to test a person's choice reaction time (that is, the time required to make a decision and perform some task) in response to the shape of a figure. You will be shown 18 sets of slides. At the start of each set of slides you will see a slide containing a single figure. This figure is the target for that particular set of slides. You will see a blank white field between each slide in the set. The following slides in the set will contain pairs of figures. One figure will always be the target. The target can appear either on the left or the right side of the slide. The figure you choose as a match for the target should be exactly the same shape as the target and in the same orientation as the target.

You have before you a black box constructed with 2 buttons on the top. You must position your hands so that one finger on your right hand is resting on the button to your right; and, one finger on your left hand is resting on the button to your left. When you see the slides containing pairs of figures, you must decide which figure is the target; then, you should press the button corresponding to the side of the slide in which the target appears.

For example:



Target Slide

Choice Slide

The correct response would be to push the left button.

At the end of each set of slides you will see two completely black slides. This will signal the end of the set of slides for the current target figure.

You will then see another target figure which will signal the beginning of another set of slides.

Figure 3-1. Instruction Sheet for the Experiment.

Equipment

The equipment used to present the slides was a Kodak Carousel 800H audio-visual projector with a built-in timer advance and a rear-projection screen. Slides were placed in the carousels so that a blank slot occurred between every two slides in the set. At the end of each two completely black slides were loaded immediately after the last slide pair. The purpose of these blank slots in the carousels was to allow a beam of light to strike a photoelectric cell placed in its path. This photocell served to close a circuit which started a Hewlett-Packard electronic timer, Model 5300A. The next slot contained the pair of figures for the discrimination task. Although the electronic timer was actually started on the slide position prior to the discrimination task, the slide carousel was advanced by an automatic timer which added a constant 5 seconds ($\pm$ .003) to the subject's choice reaction time.

The subject was seated 72 inches from the projection screen. Before him was a black box with two red buttons on top. The subject was told to position one finger on his right hand on the button to the right and one finger on his left hand on the button to his left so that he was sitting in a comfortable position. When the subject pressed either one of the response buttons, the electronic timer was stopped. The elapsed time from onset of the light beam activating the photocell switch to subject response was displayed on the timer.

The value on the timer was fed as an output boltage from the timer to a Hewlett-Packard digital recorder, model 5055A. Thus, the value appearing on the timer was printed as a digital readout by the recorder. The experimenter also used a chart to manually record the

the values appearing on the timer to serve as a cross-check for the digital recorder printer and to keep track of the order of presentation of the slides. A further use of this sheet was to note subject errors or omissions due to equipment malfunction. An example of this tally sheet is shown in Figure 3-2.

A detailed representation of the layout of the equipment and a schematic diagram of the principal components of the equipment is shown in Figures B-1 and B-2 respectively of Appendix B.

Variables

All of the dimensions of target shape which have been suggested in the literature to be moderately successful for identifying shape have been included in this experiment. These dimensions are considered the independent variables; they are:

1. area
2. perimeter
3. the ratio: perimeter/area
4. the ratio: $(\text{perimeter/area})^2$
5. length of the longest side of the figure
6. maximum dimension (length of the longest chord which can be constructed through the body of the figure)
7. number of inflection points (the points at which two sides meet to form an acute, obtuse or right angle or a point at which the radius of curvature changes)

Target areas and perimeters were measured with a planimeter.

Another measure, which was based on maximum dimension was visual angle subtended. This variable is computed by the formula:

	CAROUSEL 1 ☾	CAROUSEL 2 0	CAROUSEL 2 ○	CAROUSEL 3 ↱	CAROUSEL 4 S#II
1.	✓ R5689	✓ R6143	✓ L5780	✓ L5977	X L
2.	✓ R5660	✓ L6004	✓ R5670	✓ R5866	✓ L5903
3.	✓ R5935	✓ R5830	✓ L5704	✓ R5699	✓ L5966
4.	✓ R5757	✓ L5845	✓ R5657	✓ L6088	✓ L5833
5.	✓ L5638	✓ R6569	✓ L5651	✓ R5710	✓ R5886
6.	✓ L5726	✓ R5964	✓ L5751	✓ L5716	✓ R5928
7.	✓ L5741	✓ L5875	✓ R5716	✓ R5715	✓ R5877
8.	✓ L5730	✓ L5899	✓ R5778	✓ L5725	✓ L5818
9.	✓ R5871	X L	✓ R5744	✓ L5667	✓ R6538
10.	✓ R5705	✓ R6150	✓ L5948	✓ R5695	✓ R5849
11.	✓ R5727	✓ L6008		✓ R5662	✓ R5998
12.	✓ L5769	✓ R5803		✓ L5658	✓ L6249
13.	✓ L6011	✓ L5778		✓ L5717	✓ R5898
14.	✓ L5776	✓ R5966		✓ R5756	✓ L6130

	T#I	+	E	×	S#I
1.	✓ L5783	✓ R5801	✓ L5893	✓ R5691	✓ R5722
2.	✓ L6362	✓ R5790	✓ L5871	✓ R5675	✓ R5793
3.	✓ R6256	✓ L5824	✓ R5977	✓ L5765	✓ L5912
4.	✓ L5734	✓ R5666	✓ L5774	✓ R5779	✓ L5777
5.	✓ L5963	✓ R5764	✓ L5960	✓ L5914	✓ R5896
6.	✓ R5795	✓ R5687	✓ L5767	✓ L5680	✓ R5815
7.	✓ R5675	✓ R5744	✓ L5685	✓ R5781	✓ L5752
8.	✓ R5733	✓ L5906	✓ R5762	✓ R5644	✓ R5695
9.	✓ L5724	✓ L5705	✓ R5755	✓ L5675	✓ L5706
10.	✓ R5855	✓ L5788	✓ R5844	✓ R5665	✓ L6019
11.	✓ R6034	✓ L5679	✓ R5753	✓ R5686	✓ L5755
12.	✓ L5750	✓ L5711	✓ R5715	✓ L5734	✓ R5715
13.	✓ L5920		✓ R5765	✓ R5713	✓ L5726
14.	✓ R5943		✓ L5784	✓ L5866	✓ R5752

Order of presentation:
Carousel: 2 1 8 7 6 4 5 3

Figure 3-2. Experimenter's Tally Sheet.

	CAROUSEL 5 Δ	CAROUSEL 6 ∠#2	CAROUSEL 7 Δ	CAROUSEL 8 ∠#1
1.	✓ R 5763	✓ L 5821	✓ L 5736	✓ R 5762
2.	✓ R 5727	✓ L 5714	✓ R 5758	✓ R 6072
3.	✓ L 5850	✓ L 5706	✓ R 5837	✓ R 6018
4.	✓ L 5751	✓ R 5754	✓ L 5700	✓ L 5993
5.	✓ L 5760	✓ L 5663	✓ L 5694	✓ L 5776
6.	✓ R 5738	✓ L 5670	✓ R 5724	✓ R 5847
7.	✓ L 5660	✓ R 5903	✓ L 5693	✓ R 5748
8.	✓ R 5870	✓ L 5641	✓ R 5724	✓ R 5732
9.	✓ R 5696	✓ R 5729	✓ R 5708	✓ L 5722
10.	✓ R 5807	✓ R 5674	✓ R 5698	✓ L 5722
11.	✓ L 5685	✓ R 5703	✓ L 5672	✓ R 5736
12.	✓ R 5874	✓ R 5927	✓ L 5670	✓ L 5759
13.	✓ L 5763	✓ L 5687	✓ R 5695	✓ L 5809
14.	✓ L 5708	✓ R 5733	✓ L 5645	X L

	▭	F	□	‡ #2
1.	✓ R 6239	✓ L 5694	✓ L 5671	✓ L 6324
2.	✓ L 5708	✓ R 5713	✓ R 5703	✓ R 5872
3.	✓ R 5793	✓ R 5642	✓ R 5710	✓ L 5773
4.	✓ L 5722	✓ L 5616	✓ R 5732	✓ R 6054
5.	✓ L 5680	✓ R 5640	✓ R 5710	✓ R 5962
6.	✓ R 5673	✓ R 5624	✓ L 5667	✓ R 5820
7.	✓ R 5674	✓ L 5649	✓ R 5901	✓ L 5855
8.	✓ R 5653	✓ R 5699	✓ L 5702	✓ L 5935
9.	✓ R 5668	✓ L 5901	✓ L 5723	✓ L 5762
10.	✓ L 5809	✓ L 5620	✓ R 5719	✓ R 6187
11.	✓ R 5757	✓ R 5795	✓ L 5665	✓ L 5766
12.	✓ L 5699	✓ R 5666	✓ L 5920	✓ R 5728
13.	✓ L 5653	✓ L 5677		✓ R 5959
14.	✓ L 5682	✓ L 5608		✓ R 5902

Presentation Order

Carousel: 2 1 8 7 6 4 5 3

Figure 3-2. (Concluded)

$$\text{Visual Angle (Minutes)} = \frac{(57.3)(60)\ L}{D}$$ [1]

where L = the size of the object measured perpendicular to the line of sight and D = the distance from the eye to the object. The numbers 57.3 and 60 are constants for angles less than 600 minutes of arc. Since the size of the target viewed (by projection) was exactly twice that of the original of the target, and since the distance between the subject and the screen remained constant, the maximum dimension was used as the measure of size perpendicular to the line of sight (L in the equation). Thus, the visual angle variable was linearly related to maximum dimension.

One variable which is unique to this study is a measure devised to quantify the similarity between two shapes presented as a trial in a choice reaction task. This variable was called pattern similarity. It was measured by drawing each of the targets on a clear plastic grid marked off in one-quarter inch squares. The grid was then overlaid on the other figures in the target's comparison group as well as the target itself (to simulate the 45° and 90° rotational pairings). The squares common to the two superimposed figures were counted as were the squares enclosed by the figure on the grid overlay alone. The result was an expression of the squares common to the two figures as a percentage of the number of squares enclosed by the figure drawn on the grid.

The measures described above as independent variables were used in the following way. Each choice reaction trial consisted of discriminating between two figures on a slide: the target and the distractor.

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1. From Van Cott and Kinkade, Human Engineering Guide to Equipment Design, 1972, p. 48.

In addition, when a trial consisted of a target compared to a 45° or 90° rotation of the same figure (as the distractor), all of the independent variables drop out (since the areas, perimeters, etc. are equal) except for pattern similarity. This special case of pairing was included to provide some information on the effect of perceived pattern similarity due to angular orientation of a figure.

The dependent variable is choice reaction time. Choice reaction time was defined as the elapsed time between the onset of the stimulus pair and the onset of the subject's response. This time includes a psychophysical element where the subject detects two figures appearing in his visual field (at illumination levels and of sufficient size that they are well above threshold); it includes a mental processing element whereby the subject judges the figures by some hypothesized criteria according to shape and decides which figure is the target; and, it includes a movement time for the subject to make a motor response.

Experimental Analysis

Linear models of the form:

$$y = b_0 + b_1x_1 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9$$

where

y = the dependent variable choice reaction time

x_1 = target (t) area-distractor (d) area or (tA-dA)

x_2 = target (t) perimeter-distractor (d) perimeter or (tP-dP)

x_3 = (tP/tA - dP/dA)

x_4 = $((tP/tA)^2 - (dP/dA)^2)$

x_5 = (t side length - d side length)

x_6 = (t maximum dimension - d maximum dimension)

x_7 = (t number of inflection points - d number of inflection points)

x_8 = (t visual angle - d visual angle)

x_9 = pattern similarity between t and d of the percentage of d squares to t squares

b_0 = the y intercept

and b_1 through b_9 = the regression coefficients for the independent variables x_1 through x_9 respectively were tested using the Multiple Regression Analysis program from the Statistical Package for the Social Sciences (SPSS). A model was developed for each of the eighteen targets and for each target group. Errors or omissions were treated as missing data; this did not cause a problem, however, because error rates were very low for all subjects. (Subjects averaged 4 error responses out of 244 total responses). As previously stated, each of the fifteen subjects viewed and responded to 244 slides or a total of 122 unique treatment combinations (since each slide pair was shown once with the target on the left and once with the target on the right). Each target set had an average of seven unique treatment combinations as a result of the target being compared to the other five targets in the group and against itself at two different angular orientations. Thus, there was an average of 14 observations per target per subject or 210 observations per target.

For the first attempt to analyze the data, a stepwise regression was used in which the F-level for coefficients of entering variables was very low. In general, six of the nine variables entered the equation for each model yet R^2 values remained very low. Therefore, the second phase of the analysis involved the computation of the sums of squares pure error ($SS_{P.E.}$) to help explain the lack of fit indicated by the R^2s. $SS_{P.E.}$ should be the portion of the variation explained by two factors: random variations in the choice reaction times of the population sampled and any random variation which may be due to the left-right orientation of the target. This estimate may be calculated when there are repeat measurements made at any given combination of the independent variables. In the case of this experiment there were repeated measurements for the fifteen subjects and for left-oriented targets and right-oriented targets. Computation of the $SS_{P.E.}$ for each target and each target group revealed that the $SS_{P.E.}$ comprised a major portion of the sums of squares residual ($SS_{Residual}$). This meant there was little or no lack of fit in the model but that the variation not due to regression was due to variation in the population tested and variation due to target left/right orientation.

Including the effects of subjects as a variable in the regression analysis would not be useful because no measures were taken which would distinguish the subjects and explain the effect of population variance in the model. Also, a more general model was desired which could be hypothesized to extend to a population larger than the sample tested here. However, steps were taken to include the effect of target left/right orientation in the models whenever appropriate. An analysis of variance was conducted to determine whether there was a significant difference in target left/right orientation for the overall experiment. Then the use of a dummy variable for orientation was included in the subsequent stepwise regression analyses. F-levels for the coefficients of variables entering the model were raised; the number of variables entering the equations were restricted. A model for one of the targets was built using data for left-oriented targets only and compared to a model using data from the right oriented targets.

A limit on the R^2s (due to the amount of pure error variation in the equation) was calculated using the following formula:

$$R^2_{Limit} = \frac{SS_{Total} - SS_{P.E.}}{SS_{Total}}.$$

This formula was derived using the rationale that R^2 is usually calculated as:

$$R^2 = \frac{SS_{Total} - SS_{Residual}}{SS_{Total}}$$

In this case, however, $SS_{Residual}$ is made of two components: 1. Sums of squares lack of fit of the regression model and 2. Sums of squares pure error due to the 30 repeated measures for fifteen subjects and two target orientations at each observation of the independent variables. Thus the formula above could be expressed as:

$$R^2 = \frac{SS_{Total} - (SS_{Lack\ of\ Fit} + SS_{Pure\ Error})}{SS_{Total}.}$$

Assuming that for the best case lack of fit in the model is zero, a limit on the R^2 (due to the pure error component in the $SS_{Residual}$) may be calculated.

The R^2s resulting from the second round of regression analyses could then be reported as a proportion of the limit on the R^2s. Finally, a table was constructed showing the mean choice reaction time for each target and for each group of targets.

CHAPTER IV

RESULTS

The first step in the analysis was a stepwise regression for each target and each group of targets using an F-level of .01 (the default value of this parameter in the SPSS regression program) for the coefficients of the variables entering the equation and using essentially no limit on the number of variables allowed in the equation. Tables C-1 through C-21 of Appendix C shows summaries of the results of the final step for each regression analysis. The abbreviations used for the variables in all of the following tables are:

1. area (A)
2. perimeter (P)
3. perimeter/area ratio (PA)
4. square of the perimeter/area ratio (PA2)
5. length of the longest side (SL)
6. number of inflection points (NAGL)
7. visual angle subtended (VAGL)
8. pattern similarity (PS)
9. left-right orientation of the target (ORIENT)

Note that the variable maximum dimension was eliminated since it was linearly related to the variable expressing visual angle subtended. As these tables show, the highest R^2 resulting from these models was .368 for the block II shape.

In general, the R^2 values did not appear to reflect good prediction equations. Examination of a plot of the residuals did not show any overall non-linear trends for the models, but it did reveal some clustering of the residuals which corresponded to the data sets for individual subjects. Since there were repeated measures for the fifteen subjects and the two target orientations, $SS_{P.E.}$ was calculated for each of the models. Although the effects of subjects and target orientation are confounded in this measure, it did reveal that the residual sums of squares in the models were not due to lack of fit, but were almost totally due to pure error. Table 4-1 shows a comparison of the $SS_{P.E.}$ and the $SS_{Residual}$ for each model.

On the basis of this information, a stepwise regression was performed again for each target and each group with several major changes: 1. The F-level for the coefficients of the entering variables was raised from .01 to 2.75; 2. The number of variables which could enter the equation was limited to six; and, 3. A dummy variable which accounted for target orientation effects was introduced in the analysis. The results of these analyses are shown in Tables C-22 through C-42. Also, a one-way analysis of variance for orientation effects was computed using the "ANOVA" program from SPSS. The results indicated that the difference between left-oriented target responses and right-oriented target responses was not significant ($p > .10$). (See Table 4-2 for the ANOVA summary table).

A large portion of the variance in the residual sums of squares was due to subject variability. Since there were no subject-dependent variables in this experiment, it was not desirable to partion out the subject effects using dummy variables. Therefore, an upper limit on the R^2 which could be expected was calculated for each model. The R^2s resulting from the second analyses were expressed as a percentage of the R^2 limits. In view of this information the models were found to adequately predict choice reaction time for individual targets. Table 4-3 lists the R^2s for each of the models, the limits on the R^2s, and the percentage of the R^2 in relation to its corresponding limit.

Table C-43 in Appendix C displays the results of dividing the data for a single target into right-oriented target data and left-oriented target data. As the table shows, the multiple R values and the R^2 values derived for the two models are quite close and the same variables NAGL, (PA2 and PA) entered the equations. Mean choice reaction times and standard deviations of the choice reaction times are also approximately equal. Again, the effects due to target orientation appear not to be significant; the variance accounted for as pure error seems to be largely due to subject effects.

Table 4-4 shows the mean choice reaction time and the corresponding standard deviations for each target and each shape ranked in descending order. The five second delay between the onset of the photocell opening the circuit and the onset of the stimulus presentation has been subtracted out. The mean choice reaction times are expressed in terms of milliseconds.

The models developed as the best predictors of choice reaction time for each target and for each group of targets are:

1. Circle

$\hat{y} = 5861.128 - 38.825\ (SL)$

2. Ellipse

$\hat{y} = 6050.256 - 141.772\ (P) - 72.926\ (Orient)$

3. Triangle

$\hat{y} = 5893.551 - 347.980\ (PA2) + 1091.745\ (PA)$

4. Trapezoid

$\hat{y} = 5949.697 - 38583\ (PA2)$

5. Square

$\hat{y} = 5610.960 + 2.519\ (PS) - 34.422\ (SL)$

6. Rectangle

$\hat{y} = 5749.144 + 1.478\ (PS) - 2.522\ (VAGL)$

7. Right Turn Arrow

$\hat{y} = 5915.153 - 4.348\ (VAGL) - 143.061\ (PA) + 2.918\ (PS)$

8. Crescent

$\hat{y} = 5959.935 - 16.5\ (NAGL)$

9. Cross

$\hat{y} = 5865.764 - 21.509\ (P) - 9.778\ (NAGL)$

10. X

$\hat{y} = 5862.882 - 7.208\ (NAGL) - 12.12\ (P)$

11. E

$\hat{y} = 5836.688 - 90.838\ (PA)$

12. F

$\hat{y} = 5856.813 - 38.724\ (SL)$

13. Curve I

$\hat{y} = 5454.372 - 75.381\ (SL) + 5.467\ (PS)$

14. Curve II

$$\hat{y} = 5436.472 + 6.338\ (PS) - 83.054\ (SL) - 4.494\ (NAGL)$$
$$+ 64.644\ (Orient)$$

15. Angle I

$$\hat{y} = 5988.380 - 69.469\ (SL) = 5.820\ (PA2)$$

16. Angle II

$$\hat{y} = 5896.113 - 86.422\ (SL) + 129.518\ (A)$$

17. Block I

$$\hat{y} = 5000.0 - 35.4449\ (P) + 9.2141\ (PS)$$

18. Block II

$$\hat{y} = 5973.93 - 19.359\ (NAGL) + 265.466\ (PA2) - 1500.717\ (PA)$$

19. Geometric Shapes

$$\hat{y} = 5000.0 - 22.8164\ (SL) + 1.2306\ (PS) - 2.0850\ (VAGL)$$
$$- 14.5483\ (PA2)$$

20. Symbol Shapes

$$y = 5860.931 - 6.248\ (NAGL) - 34.967\ (A) + 1.087\ (PS) - 1.062\ (VAGL)$$

21. Nonsense Shapes

$$y = 6000.0 - 23.5748\ (P) - 55.8119\ (SL) + 106.7171\ (PA2) - 700\ (PA)$$
$$+ 10.9084\ (VAGL) + 6.2632\ (NAGL)$$

The order of the variables in these equations is the same order that the variables entered the equation in the stepwise regression.

Table 4-1. Comparison of Residual Sums of Squares from the Final Regression Analysis and Pure Error Sums of Squares for the Experiment.

Target	$SS_{Residual}$	$SS_{Pure\ Error}$
Circle	4189959.873	4109071.8
Ellipse	13490000.0	13276538.0
Triangle	6268513.354	6158934.8
Trapezoid	10190000.0	9814829.6
Square	9810107.525	9795388.7
Rectangle	7621851.828	75603 .
Right Turn Arrow	9860515.536	9764075.2
Crescent	11080000.0	10855628.0
Cross	4711435.959	4698844.5
X	4625548.488	4577321.0
E	5856413.343	5737309.3
F	6636730.453	6598062.2
Curve I	8320391.395	8104962.4
Curve II	14780000.0	14743893.7
Angle I	6927210.766	6720372.5
Angle II	9534613.584	9281898.1
Block I	15950000.0	20880809.0
Block II	21290000.0	15859935.0
Group		
Geometric Shapes	53770000.0	50715086.0
Symbol Shapes	44910000.0	42231240.5
Nonsense Shapes	85910000.0	77294563.0

Table 4-2. ANOVA Table for the Effects of Left/Right Target Orientation.

```
- - - BREAKDOWN - - -

CRITERION VARIABLE    TIME
    BROKEN DOWN BY    ORIENT

    VARIABLE         CODE          MEAN    STD. DEV.       N VALUE LABEL

FOR ENTIRE POPULATION          5664.799     245.146    3591
ORIENT                  0      5559.466     254.620    1825
ORIENT                  1.     5771.341     234.847    1766

TOTAL CASES =     3660
MISSING CASES =        69 OR    1.9 PCT.

ANALYSIS OF VARIANCE

SOURCE            D.F.  SUM OF SQRS MEAN SQUARES        F RATIO   F PROB.

BETWEEN GROUPS      1      148766.26    148766.26         2.476      .116
WITHIN GROUPS    3589 215597470.97     60071.74
         TOTAL   3590 215746237.22
```

Table 4-3. Comparison of Regression R^2s and Percentage of the Upper Limit on the R^2s Obtained in the Final Regression Analysis.

Target	R^2	R^2 Limit	Percentage of R^2 Limit
Circle	.0461	.0645	71.47
Ellipse	.1096	.1237	88.60
Triangle	.0737	.0899	81.98
Trapezoid	.0654	.0999	65.47
Square	.2053	.2065	99.42
Rectangle	.2132	.2195	97.13
Right Turn Arrow	.1746	.1827	95.57
Crescent	.1107	.1288	85.95
Cross	.0666	.0691	96.38
X	.0855	.0951	89.91
E	.0727	.0916	79.37
F	.0455	.0511	89.04
Curve I	.1290	.1516	85.09
Curve II	.1723	.1744	98.79
Angle I	.1745	.1991	87.64
Angle II	.1934	.2089	80.35
Block I	.1934	.2089	94.58
Block II	.3647	.3683	99.02
Group	**R^2**	**R^2 Limit**	**Percentage of R^2 Limit**
Geometric Shapes	.1304	.1798	72.53
Symbol Shapes	.0736	.1289	57.10
Nonsense Shapes	.1316	.2187	60.17

Table 4-4. Mean Choice Reaction Times and Standard Deviations for Each Target and Each Group of Shapes (in Milliseconds).

Target	Mean (in millisec.)	Standard Deviations
Block	953.513	349.146
Curve II	949.883	295.232
Block II	933.087	358.863
Ellipse	912.089	274.639
Curve I	907.962	214.306
Angle I	893.332	201.341
Rectangle	882.024	216.326
Trapezoid	877.048	229.617
Angle II	875.237	226.490
Square	865.800	262.605
Crescent	849.407	244.836
Right Turn Arrow	848.165	252.757
Triangle	819.919	180.371
F	813.183	183.276
X	803.298	157.465
Cross	793.433	167.927
E	789.428	177.701
Circle	758.940	171.699
Group	**Mean (in millisec.)**	**Standard Deviations**
Nonsense Shapes	918.835	274.229
Geometric Shapes	852.636	222.543
Symbol Shapes	816.152	197.327

CHAPTER V

DISCUSSION

In general models predicted choice reaction time with R^2s of from 65 percent to 99 percent of the R^2 limits. Models for the nonsense figures shapes were particularly good in view of the amount of variation they could be expected to explain. The models demonstrated that a wide variety of variables were used to explain choice reaction time to shape. Each of the variables hypothesized to influence choice reaction time were used in at least one model.

The best regression models which could be derived to predict choice reaction time for groups of shapes were inferior according to criteria of R^2s or R^2 limits. The wide variety of variables entering the models developed for individual targets indicate that different aspects of shape influence discriminations for targets in the same category.

It should be noted that of the independent variables, length of the longest side (SL) and pattern similarity (PS) occurred most frequently in the models. Both of these variables entered one third of the individual target models and two of the group models. The square of the perimeter/area ratio and the number of inflection points also appeared in several of the models. One interesting point is that there was a noticeable tendency for the same variables to be used in models for targets constructed to be highly similar. For example, the models for both the square and the rectangle have the variable pattern similarity;

the model for Curve I contains the variables pattern similarity and and side length as does the model for Curve II.

The circle is an interesting special case in the study of shape. As predicted by many Gestalt or psychophysical theories, the circle was the easiest target to discriminate from other figures; it had the shortest mean choice reaction time. The variable which proved to be useful in predicting this choice reaction time was length of the longest side. The length of the longest side for the circle was zero. However, every other figure used in comparison with the circle had a side length greater than zero. Rather than basing this choice reaction time result on psychophysical diffusion models or "good Gestalts", it may be postu- that the circle can be quickly discriminated as the only figure which does not have an edge.

One conclusion about the results of this experiment may be that the physical parameters for determing choice reaction time to individual shapes may be readily used for prediction. But, the psychological factors determining which physical parameters are valuable in making a shape discrimination are not yet obvious. Although the mean choice reaction times for target and groups of targets fall in the approximate order expected, the subjects seem to be using different sets of cue to discriminate targets in the same group. On highly similar targets, however, the same set or similar subsets of cues appear to be operational. Perhaps what is needed is further definition or refinement of the classification scheme for groups of targets.

In terms of the percentage of the R^2 limits obtained, the individual prediction models for the nonsense shapes were slightly better.

Perhaps this is because recognition of unfamiliar shapes depend more on the cues of physical parameters such as those represented by the independent variables than on semantic cues which were hypothesized to exist but were not measured directly.

Fugure studies of this sort should test subjects using a wide range of targets. The targets could be constructed so that their perceived differences varied from highly similar to highly dissimilar. One could then develop prediction equations for each target and one could group targets according to similarities in their individual prediction equations. By discovering which physical parameters constitute operational cues for shape recognition and by clustering similarly perceived shapes, perhaps a definition of underlying psychosocial or semantic cues will emerge.

APPENDICES

APPENDIX A

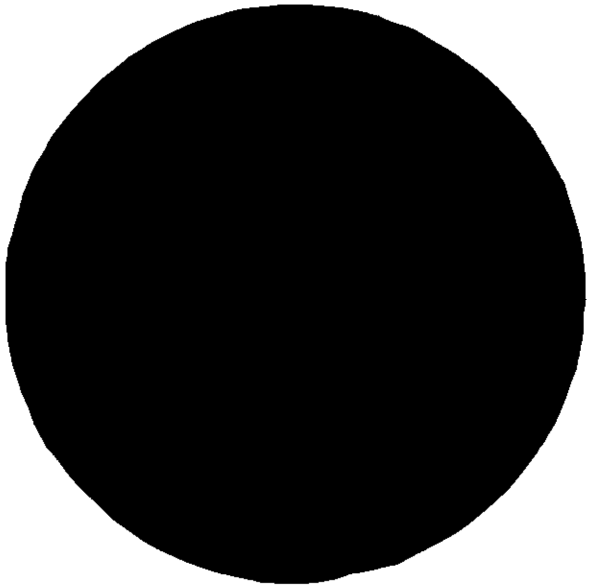

Figure A-1. Circle.

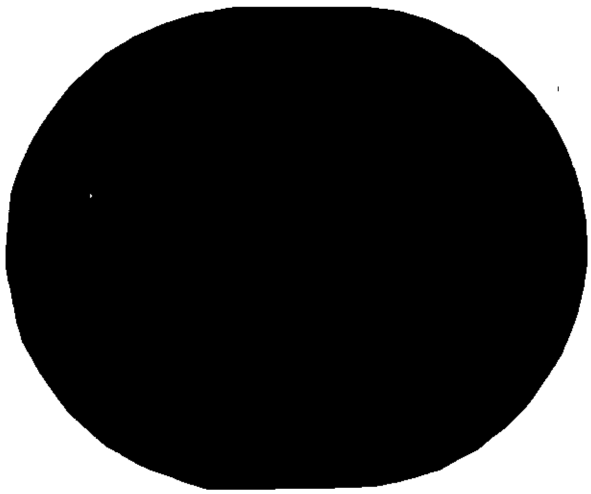

Figure A-2. Ellipse.

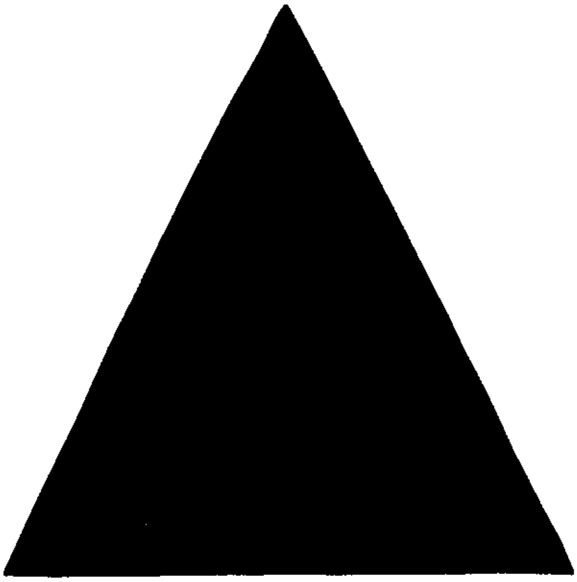

Figure A-3. Triangle.

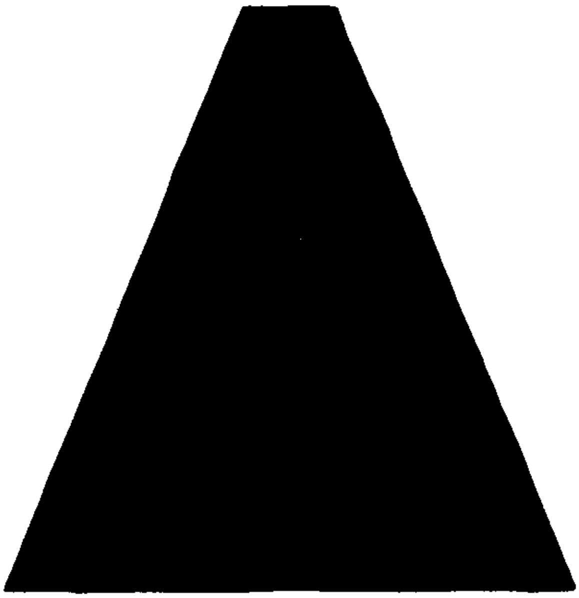

Figure A-4. Trapezoid.

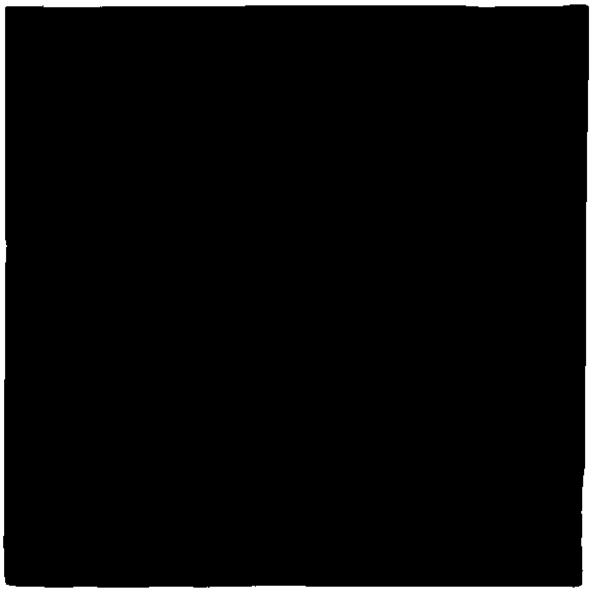

Figure A-5. Square.

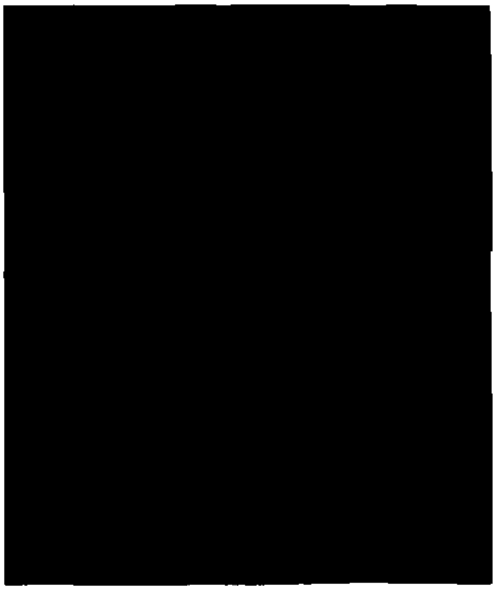

Figure A-6. Rectangle.

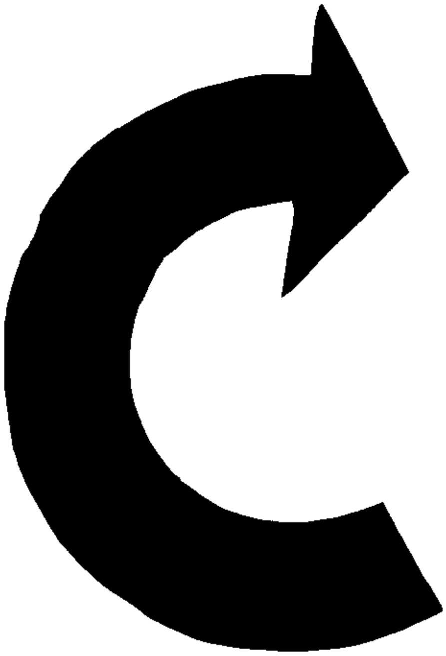

Figure A-7. Right Turn Arrow.

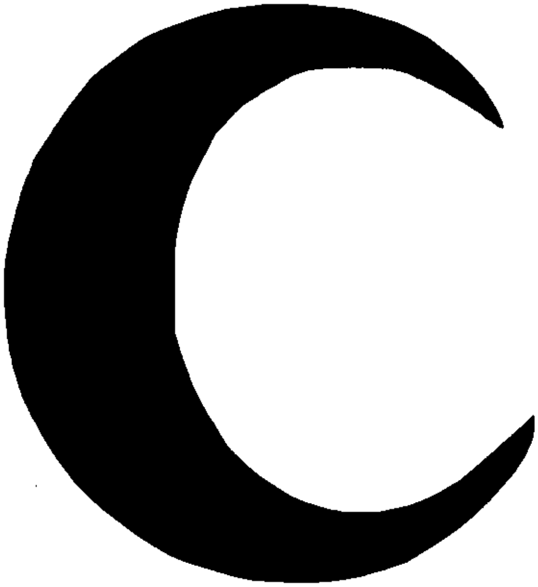

Figure A-8. Crescent.

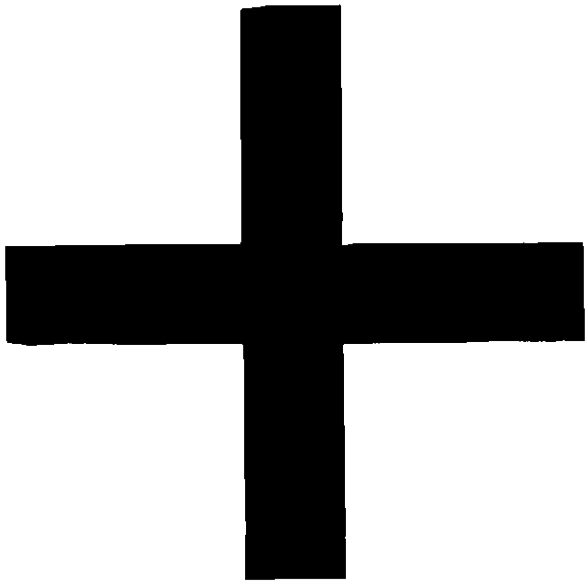

Figure A-9. Cross.

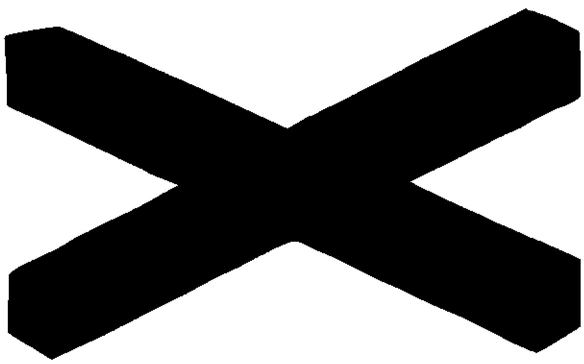

Figure A-10. X.

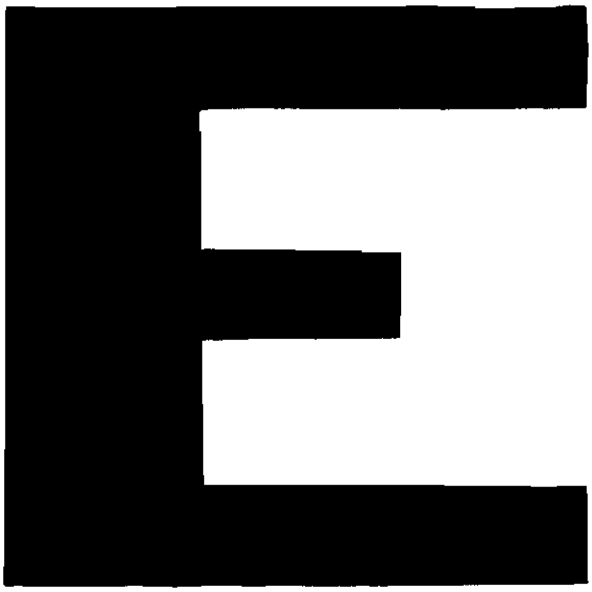

Figure A-11. E.

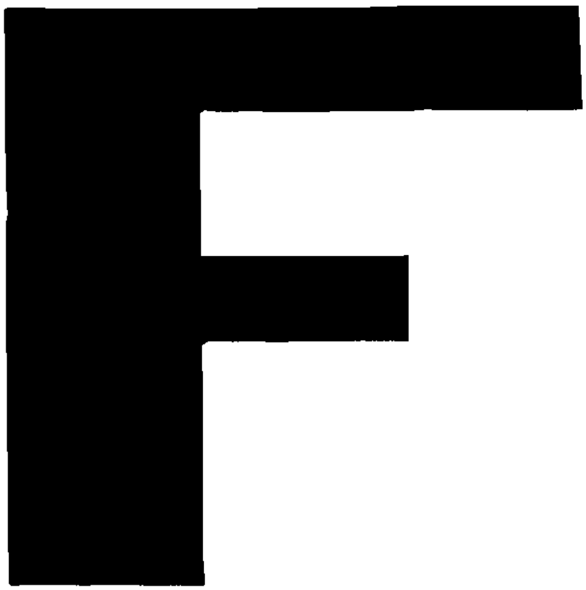

Figure A-12. F.

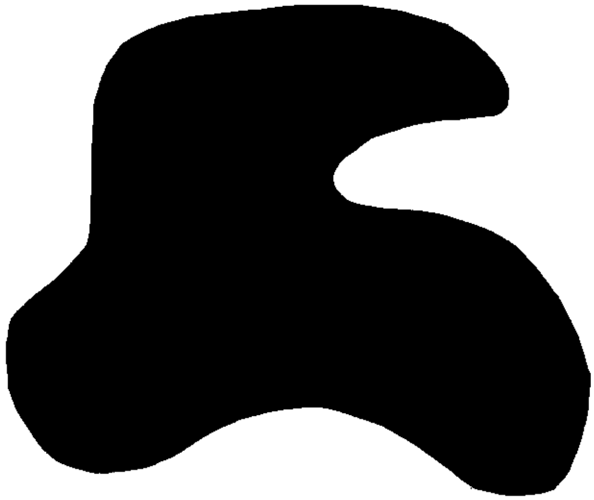

Figure A-13. Curve I.

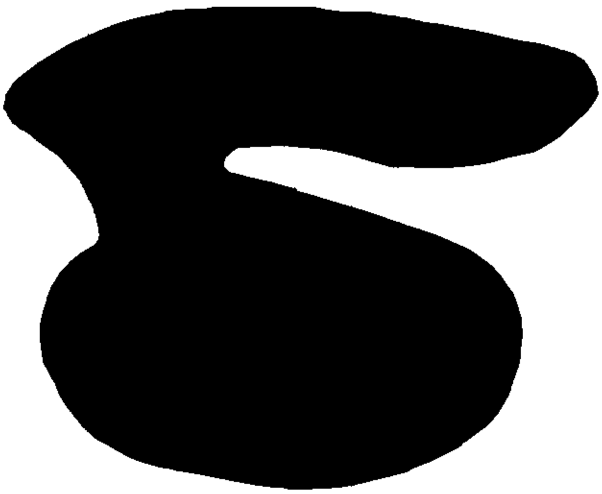

Figure A-14. Curve II.

Figure A-15. Angle I.

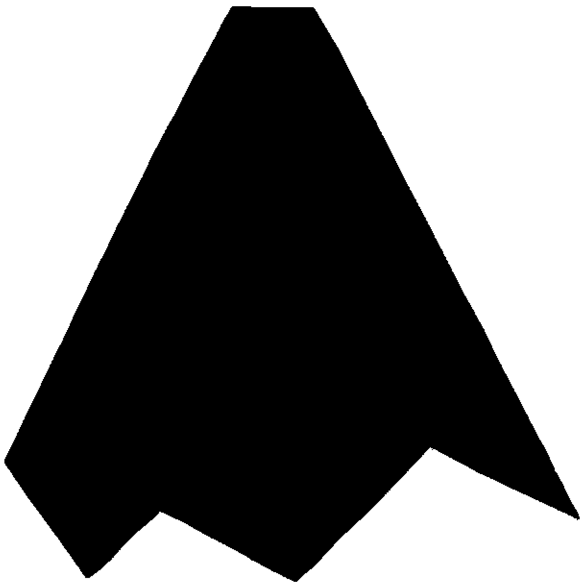

Figure A-16. Angle II.

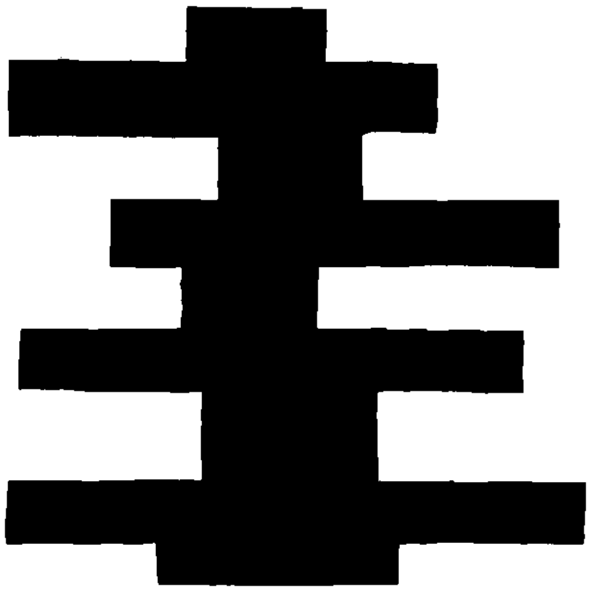

Figure A-17. Block I.

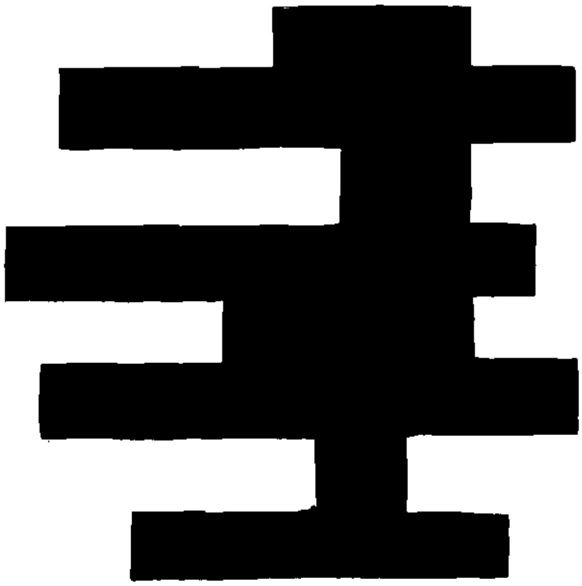

Figure A-18. Block II.

APPENDIX B

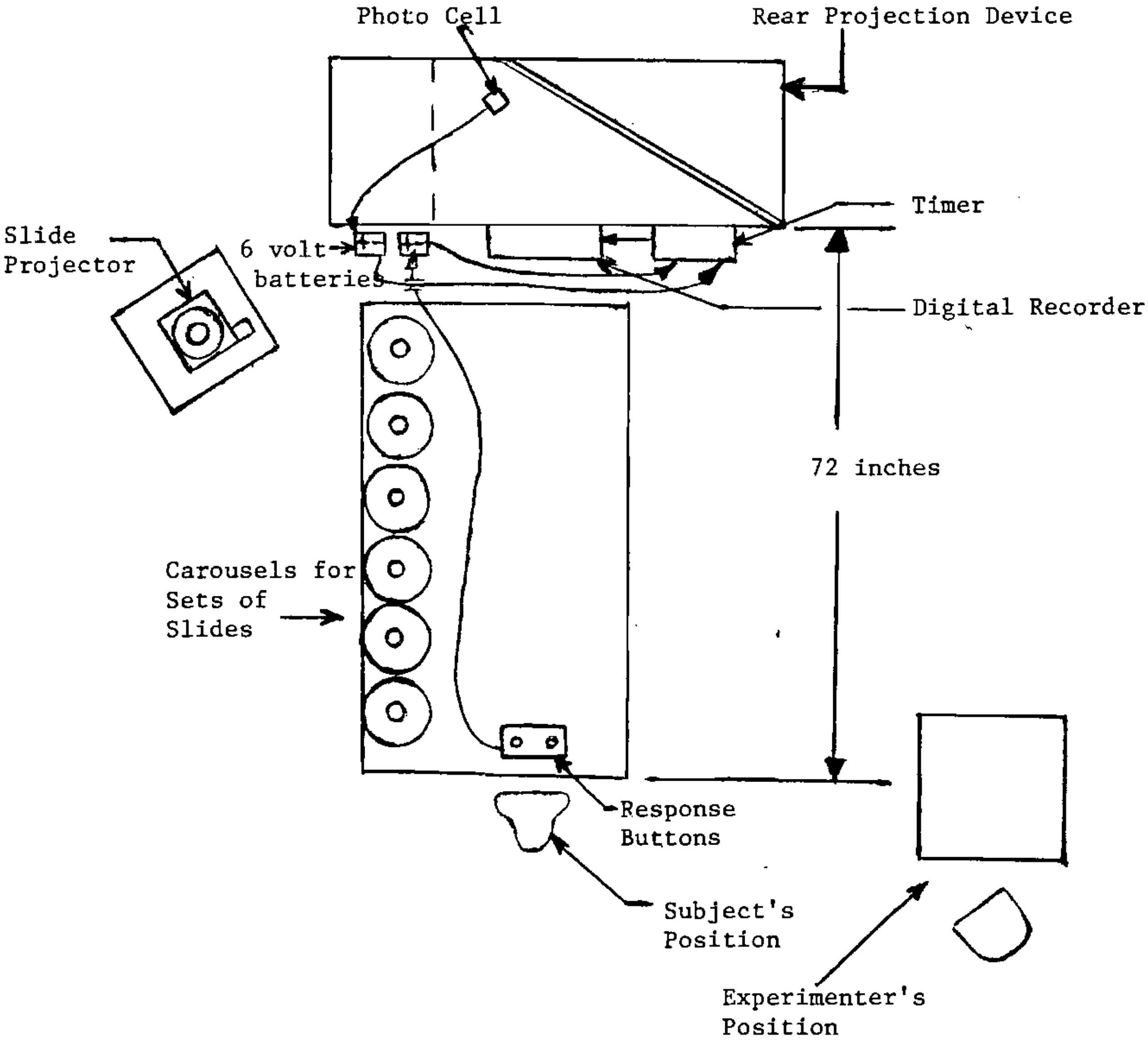

Figure B-1. Plan View Diagram of Experimental Equipment Arrangement.

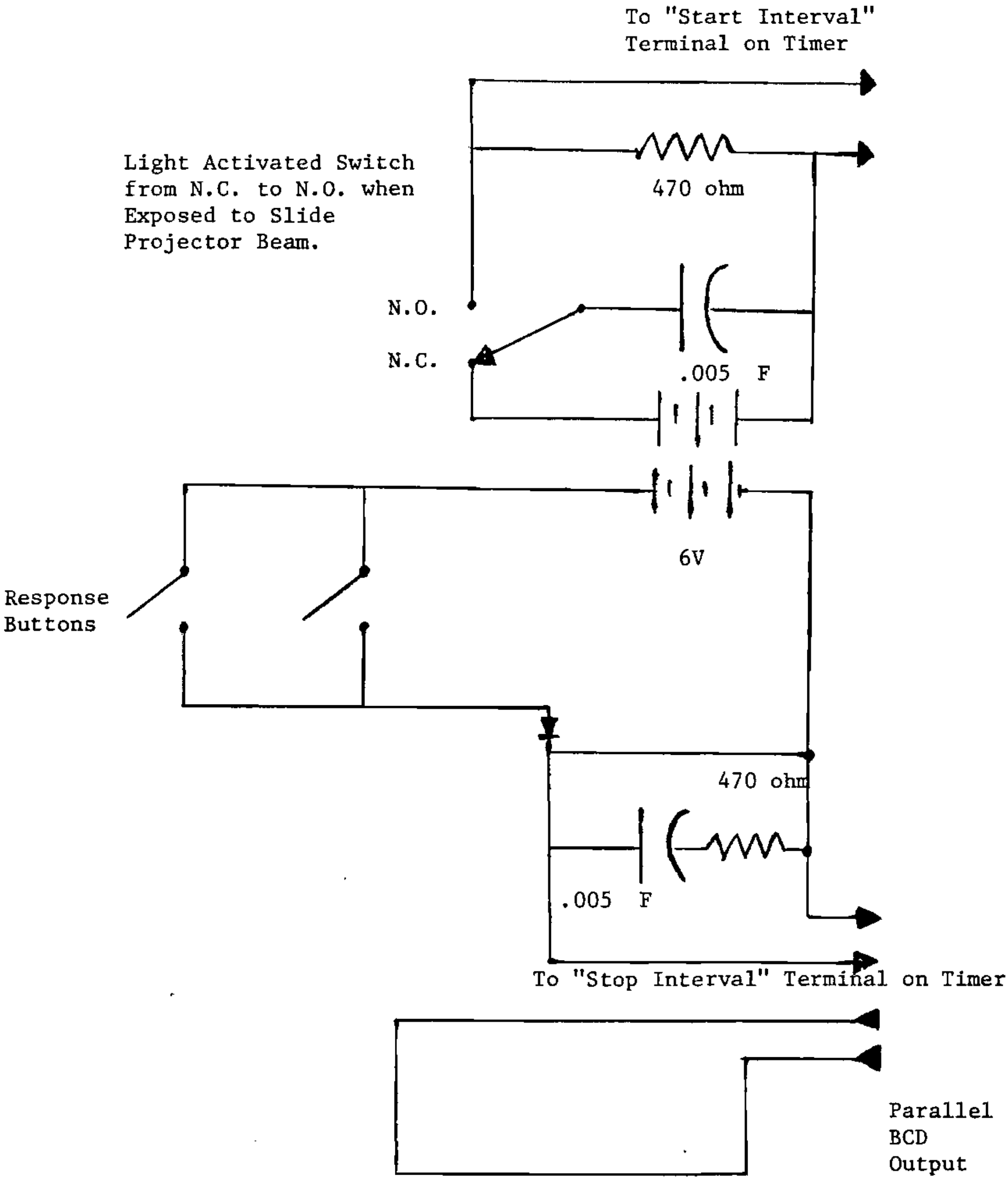

Figure B-2. Electrical Schematic Diagram of Experimental Equipment.

APPENDIX C

Table C-1. Initial Regression Analysis Results for the Circle Target.

Dependent Variable . . . Time

Mean Response 5758.94000 Std. Dev. 171.69871

Final Step.

Multiple R	.2541	ANOVA	of Sum Squares	Mean Sq.	F
R. Square	.0645	Regression	4. 283519.560	70879.890	2.501
Std. Dev.	168.3401	Residual	145. 4109066.900	28338.392	Sig. 045
Adj. R. Square	.0387	Coeff. of Variability	2.9 pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
SL	50.563	44.341	1.300	.256	.27971	-.02311
PA^2	-144.352	531.840	.074	.786	-1.17986	.04060
PS	12.524	52.799	.056	.813	1.34805	.21705
NAGL	186.029	960.355	.038	.847	.43484	-.12275
Constant	5115.151	2380.876	4.616	.033		

Table C-2. Initial Regression Analysis Results for the Ellipse Target.

Dependent Variable . . . Time

Mean Response 5912.08911 Std. Dev. 274.63874

Final Step.

Multiple R	.3525	ANOVA	of Sum Squares	Mean Sq.	F
R. Square	.1243	Regression	6. 1884149.666	.31E+06	4.612
Std. Dev.	260.9309	Residual	195. .1327E+08	68084.947	Sig. 000
Adj. R. Square	.0973	Coeff. of Variability	4.4 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
SL	302.709	318.421	.904	.343	1.44629	-.06395
P	137.989	176.684	.610	.436	.42384	-.00891
PS	17.572	11.192	2.465	.118	.90835	.28389
PA	-1206.790	1396.388	.747	.389	-1.60431	.00023
VAGL	-15.706	20.323	.597	.441	-1.26904	.05416
A	15.967	130.808	.015	.903	.08510	-.00134
Constant	4350.841	1051.248	17.129	.000		

Table C-3. Initial Regression Analysis Results for the Triangle Target.

Dependent Variable . . . Time

Mean Response 5819.91866 Std. Dev. 180.37133

Final Step.

Multiple R	.2998	ANOVA		of Sum Squares	Mean Sq.	F
R. Square	.0899	Regression	6.	608080.892	.10E+06	3.324
Std. Dev.	174.6135	Residual	202.	6158952.725	30489.865	Sig. 004
Adj. R. Square	.0628	Coeff. of Variability		3.0 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
PA^2	75.989	163.558	.216	.643	.59918	.01767
PS	-4.581	4.134	1.228	.269	-.44773	-.05466
A	-1057.488	1437.903	.541	.463	-9.48944	.33906
SL	-1488.810	2046.239	.529	.468	-10.38195	-.20636
VAGL	108.092	150.635	.515	.474	12.49634	-.14513
NAGL	-168.764	250.680	.453	.502	-1.27409	.00416
Constant	6083.297	177.534	1174.125	0		

Table C-4. Initial Regression Analysis Results for the Trapezoid Target.

Dependent Variable . . . Time

Mean Response 5877.04808 Std. Dev. 229.61698

Final Step.

Multiple R	.3173	ANOVA		of Sum Squares	Mean Sq.	F
R. Square	.1007	Regression	6.	1099021.386	.18E+06	3.751
Std. Dev.	220.9752	Residual	201.	9814838.133	48830.040	Sig. .001
Adj. R. Square	.0739	Coeff. of Variability		3.8 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
PA^2	-270.241	170.191	2.521	.114	-1.79150	-.08658
NAGL	12.200	23.631	.267	.606	.07209	.00142
SL	361.037	285.776	1.596	.208	1.97572	.05583
P	245.059	171.628	2.039	.155	.97958	.04230
VAGL	-26.546	19.043	1.943	.165	-2.37337	.00104
PS	-5.730	5.706	1.009	.316	-.39775	-.08488
Constant	6293.600	359.316	306.792	0		

Table C-5. Initial Regression Analysis Results for the Square Target.

Dependent Variable . . . Time

Mean Response 5865.80000 Std. Dev. 262.60516

Final Step.

Multiple R	.4544	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.2065	Regression	5.	2548724.467	.50E+06	9.055
Std. Dev.	237.2663	Residual	174.	9795378.333	56295.278	Sig. 000
Adj. R. Square	.1837	Coeff. of Variability		4.0 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
PS	2.343	.605	14.996	.000	.37223	.04556
SL	-28.476	79.728	.128	.721	-.14215	-.00392
PA^2	106.494	238.147	.200	.655	.57434	-.02442
PA	-363.348	908.585	.160	.690	-.54119	.02417
VAGL	-.610	4.298	.020	.887	-.05163	-.00372
Constant	5644.816	91.153	3834.924	.000		

Table C-6. Initial Regression Analysis Results for the Rectangle Target.

Dependent Variable . . . Time

Mean Response 5882.02404 Std. Dev. 216.32619

Final Step.

Multiple R	.4686	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.2195	Regression	6.	2126673.310	.35E+06	9.423
Std. Dev.	193.9420	Residual	201.	7570309.570	37613.480	Sig..000
Adj. R. Square	.1962	Coeff. of Variability		3.3 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
PS	1.977	.525	14.162	.000	.45038	.04304
SL	-380,.467	165.306	5.297	.002	-2.19664	-.04524
PA2	191.212	198.380	.929	.336	1.19297	-.02684
VAGL	23.385	11.021	4.502	.035	2.36893	.07188
P	-144.691	68.871	4.414	.037	-.54607	-.00148
PA	202.689	742.843	.074	.785	.34853	-.00752
Constant	5682.963	80.417	4994.060	0		

Table C-7. Initial Regression Analysis Results for the Right Turn Arrow Target.

Dependent Variable . . . Time

Mean Response 5848.16489 Std. Dev. 252.75714

Final Step.

Multiple R	.4290	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.1840	Regression	6.	2198656.912	.36E+06	6.804
Std. Dev.	232.0704	Residual	181.	9748056.976	53856.668	Sig.000
Adj. R. Square	.1570	Coeff. of Variability		4.0 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
VAGL	13.029	7.277	3.205	.075	.89166	-.04848
PA^2	8.325	13.394	.386	.535	.12672	-.00267
PS	11.587	6.514	3.164	.077	.48982	.05694
NAGL	-38.138	24.499	2.423	.121	-.61623	.01821
P	27.903	32.013	.760	.385	.21746	-.00180
SL	-55.147	126.760	.189	.664	-.19306	.00536
Constant	5686.979	174.382	1063.557	0		

Table C-8. Initial Regression Analysis Results for the Crescent Target.

Dependent Variable . . . Time

Mean Response 5849.40670 Std. Dev. 244.83818

Final Step.

Multiple R	.3597	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.1294	Regression	6.	1613073.620	.26E+06	5.003
Std. Dev.	231.8206	Residual	202.	.1085E+08	53740.786	Sig.000
Adj. R. Square	.1035	Coeff. of Variability		4.0 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
NAGL	23.607	9.165	6.635	.011	.47613	-.02703
VAGL	-5.863	6.398	.840	.361	-.37594	.01415
SL	133.244	94.860	1.973	.162	.53701	-.02304
A	-89.516	100.385	.795	.374	-.35319	.01112
PA^2	3.912	20.260	.037	.847	.07435	.00385
PS	-1.336	10.432	.016	.898	-.06759	-.00640
Constant	6009.457	228.565	691.273	.000		

Table C-9. Initial Regression Analysis Results for the Cross Target.

Dependent Variable . . . Time

Mean Response 2793.43333 Std. Dev. 167.92653

Final Step.

Multiple R	.2629	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.0691	Regression	5.	348827.667	69765.533	2.583
Std. Dev.	164.3316	Residual	174.	4698850.533	27004.888	Sig.028
Adj. R. Square	.0424	Coeff. of Variability		2.8	Pct	

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
P	36.499	13.677	7.122	.008	.44219	-.01011
PS	23.660	10.255	5.322	.022	.77000	.06950
VAGL	4.366	2.461	3.147	.078	.40984	.00120
PA^2	-62.397	86.193	.524	.470	-1.60994	-.04819
PA	416.242	660.242	.397	.529	1.38916	.04225
Constant	5476.818	151.320	1309.983	0		

Table C-10. Initial Regression Analysis Results for the X Target.

Dependent Variable . . . Time

Mean Response 5803.29756 Std. Dev. 157.46492

Final Step.

Multiple R	.3083	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.0951	Regression	6.	480905.770	80150.962	3.467
Std. Dev.	152.0452	Residual	198.	4577315.079	23117.753	Sig. .003
Adj. R. Square	.0677	Coeff. of Variability		2.6	Pct	

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
NAGL	-2.151	6.337	.115	.735	-.06392	-.00195
P	16.432	10.227	2.581	.110	.21337	-.00507
PS	2.360	2.998	.620	.432	.07780	.01068
VAGL	-1.694	2.714	.390	.533	-.16480	-.00341
SL	14.941	55.111	.073	.787	.08481	-.00062
PA^2	1.911	7.479	.065	.799	.08481	.00000
Constant	5805.455	79.202	5372.801	.000		

Table C-11. Initial Regression Analysis Results for the E Target.

Dependent Variable . . . Time

Mean Response 5789.42786 Std. Dev. 177.70078

Final Step.

Multiple R	.3026	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.0916	Regression	6.	578194.329	96365.721	3.258
Std. Dev.	171.9704	Residual	194.	5737318.875	29573.809	Sig.004
Adj. R. Square	.0635	Coeff. of Variability		3.0 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
PA	4663.253	3131.770	2.217	.138	14.68744	-.39112
PS	-6.439	3.992	2.602	.108	-.46779	-.04330
PA^2	-556.490	378.236	2.165	.143	-13.51606	.35387
SL	220.267	157.883	1.946	.165	1.24958	.04318
VAGL	-5.190	3.792	1.873	.173	-.44027	-.01016
A	-19.735	36.717	.289	.592	-.12355	-.00529
Constant	6095.277	153.567	1575.398	.000		

Table C-12. Initial Regression Analysis Results for the F Target.

Dependent Variable . . . Time

Mean Response 5813.18269 Std. Dev. 183.27603

Final Step.

Multiple R	.2243	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.0503	Regression	5.	349835.280	69967.056	2.140
Std. Dev.	180.8029	Residual	202.	6603315.778	32689.682	Sig.062
Adj. R. Square	.0268	Coeff. of Variability		3.1 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
SL	-38.287	38.016	1.014	.315	-.21092	-.00742
PA^2	-43.659	75.884	.331	.566	-1.03877	.03141
PA	320.601	609.710	.276	.600	.99445	-.03135
PS	-1.497	4.470	.112	.738	-.08608	-.00706
P	-7.976	31.144	.066	.798	-.08146	-.00048
Constant	5899.845	112.664	2742.259	0		

Table C-13. Initial Regression Analysis Results for the Curve I Target.

Dependent Variable . . . Time

Mean Response 5907.96172 Std. Dev. 214.30623

Final Step.

Multiple R	.3893	ANOVA		of Sum Squares	Mean Sq.	F
R. Square	.1516	Regression	6.	1447884.312	.24E+06	6.014
Std. Dev.	200.3087	Residual	202.	8104965.382	40123.591	Sig.000
Adj. R. Square	.1264	Coeff. of Variability		3.4 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
SL	105.206	27.315	14.835	.000	.42725	-.01321
PS	-.079	3.056	.001	.979	-.00346	-.00125
NAGL	-1.306	4.300	.092	.762	-.07494	.00229
PA^2	-76.823	44.221	3.018	.084	-2.54392	.04803
P	118.354	70.984	2.780	.097	2.73921	-.03405
A	-258.481	162.859	2.519	.114	.40996	-.01376
Constant	5978.534	285.638	438.085	.000		

Table C-14. Initial Regression Analysis Results for the Curve II Target.

Dependent Variable . . . Time

Mean Response 5949.88350 Std. Dev. 295.23216

Final Step.

Multiple R	.4114	ANOVA		of Sum Squares	Mean Sq.	F
R. Square	.1693	Regression	6.	3024332.696	.50E+06	6.757
Std. Dev.	273.1160	Residual	199.	.1484E+08	74592.374	Sig.000
Adj. R. Square	.1442	Coeff. of Variability		4.6 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
PS	-1.420	7.052	.041	.841	-.05228	-.02207
SL	21.776	85.514	.065	.799	.06511	-.00306
NAGL	24.253	19.166	1.601	.207	.96491	-.02448
P	-112.376	141.205	.633	.427	-1.95066	.06471
PA^2	46.978	67.592	.483	.488	1.15126	-.03607
VAGL	-14.181	24.639	.331	.566	-.18696	-.01004
Constant	6134.400	612.175	100.414	0		

Table C-15. Initial Regression Analysis Results for the Angle I Target.

Dependent Variable . . . Time

Mean Response 5893.33173 Std. Dev. 201.34137

Final Step.

Multiple R	.4198	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.1763	Regression	3.	1479146.995	.49E+06	14.551
Std. Dev.	184.0755	Residual	204.	6912291.115	33883.780	Sig..000
Adj. R. Square	.1642	Coeff. of Variability		3.1 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
SL	-73.206	15.684	21.787	.000	-.32846	-.01194
PA^2	12.880	10.795	1.424	.234	.46533	-.01062
P	-10.405	15.680	.440	.508	-.26322	.00519
Constant	5995.702	22.311	72217.134	.000		

Table C-16. Initial Regression Analysis Results for the Angle II Target.

Dependent Variable . . . Time

Mean Response 5875.23671 Std. Dev. 226.48984

Final Step.

Multiple R	.3487	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.1216	Regression	5.	1284908.518	.25E+06	5.565
Std. Dev.	214.8979	Residual	201.	9282406.883	46181.129	Sig.000
Adj. R. Square	.0997	Coeff. of Variability		3.7 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
SL	-75.159	23.235	10.463	.001	-.29979	-.01248
A	-255.686	130.416	3.844	.051	-.41994	.02131
NAGL	-10.485	4.729	4.917	.028	-.55417	.01266
P	54.751	55.251	.982	.323	1.27723	-.04218
PA^2	-23.303	34.969	.444	.506	-.74634	.01844
Constant	5888.475	27.977	44298.914	0		

Table C-17. Initial Regression Analysis Results for the Block I Target.

Dependent Variable . . . Time

Mean Response 5933.08738 Std. Dev. 358.86275

Final Step.

Multiple R	.4553	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.2073	Regression	4.	5472878.238	.13E+07	13.141
Std. Dev.	322.6717	Residual	201.	.2092E+08	.10E+06	Sig..000
Adj. R. Square	.1915	Coeff. of Variability		5.4 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
NAGL	-10.653	8.300	1.648	.201	-.37646	-.02284
PS	6.604	4.354	2.300	.131	.20668	.08525
SL	13.698	28.059	.238	.626	.03120	.00025
PA	-46.868	107.199	.191	.662	-.15774	-.01254
Constant	5635.774	272.149	428.838	0		

Table C-18. Initial Regression Analysis Results for the Block II Target.

Dependent Variable . . . Time

Mean Response 5953.51208 Std. Dev. 349.14604

Final Step.

Multiple R	.6070	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.3684	Regression	6.	9252050.572	.15E+07	19.445
Std. Dev.	281.6022	Residual	200.	.1585E+08	79299.796	Sig.000
Adj. R. Square	.3495	Coeff. of Variability				

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
PA^2	-243.700	68.402	12.693	.000	-5.21729	-.26328
PA	1472.585	526.140	7.834	.006	4.68001	.25738
NAGL	.588	7.404	.006	.937	.02273	.00168
PS	5.640	5.867	.924	.338	.07991	.06733
SL	33.416	37.170	.808	.370	.07969	-.00258
A	10.114	74.548	.018	.892	.00902	-.00003
Constant	5593.333	397.502	197.999	0		

Table C-19. Initial Regression Analysis Results for the Geometric Shapes Group.

Dependent Variable . . . Time

Mean Response 5869.42021 Std. Dev. 239.07070

Final Step.

Multiple R	.2318	ANOVA		of Sum Squares	Mean Sq.	F
R. Square	.0537	Regression	3.	1728851.595	.57E+06	10.599
Std. Dev.	233.1818	Residual	560.	.3044E+08	54373.750	Sig.000
Adj. R. Square	.0487	Coeff. of Variability		4.0 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
PS	1.292	.281	21.066	.000	.18871	.02171
NAGL	16.529	6.658	6.163	.013	.13929	-.00020
SL	-1.345	7.481	.032	.857	-.01009	.00002
Constant	5743.047	29.462	37998.092	0		

Table C-20. Initial Regression Analysis Results for the Symbol Shapes Group.

Dependent Variable . . . Time

Mean Response 5823.19449 Std. Dev. 222.95165

Final Step.

Multiple R	.0685	ANOVA		of Sum Squares	Mean Sq.	F
R. Square	.0047	Regression	4.	143770.078	35942.520	.722
Std. Dev.	223.1533	Residual	612.	.3047E+08	49797.403	Sig..577
Adj. R. Square	-.0018	Coeff. of Variability		3.8 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
SL	-6.803	13.791	.243	.622	-.03869	-.00000
PS	.502	.772	.424	.515	.02670	.00240
P	-1.847	5.652	.107	.744	-.02267	-.00001
NAGL	-.525	2.139	.060	.806	-.01399	.00001
Constant	5809.203	23.329	62006.510	0		

Table C-21. Initial Regression Analysis Results for the Nonsense Shapes Group.

Dependent Variable . . . Time

Mean Response 5929.00166 Std. Dev. 327.04814

Final Step.

Multiple R	.1272	ANOVA	of	Sum Squares	Mean Sq.	F
R. Square	.0162	Regression	5.	1042497.309	.20E+06	1.965
Std. Dev.	325.7454	Residual	597.	.6334E+08	.10E+06	Sig.082
Adj. R. Square	.0080	Coeff. of Variability		5.5 Pct		

Variable	B	S.E.B.	F	Sig.	Beta	Elasticity
VAGL	11.218	4.722	5.644	.018	.16864	.00003
PS	-.898	.709	1.606	.206	-.05848	-.01407
P	13.059	20.873	.391	.532	.27999	.00008
PA	-55.127	90.944	.367	.545	-.24555	-.00008
NAGL	.383	2.511	.023	.879	.01908	.00000
Constant	6012.175	67.146	8017.108	0		

Table C-22. Final Regression Analysis Results for the Circle Target.

\- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5758.9400	171.6987	150
ORIENT	.5000	.5017	150
A	1.7520	1.0224	150
P	1.0320	.6701	150
VAGL	28.6498	21.3422	150
PA	.4704	.3830	150
PA2	1.6196	1.4034	150
NAGL	3.8000	.4013	150
SL	2.6320	.9498	150
PS	99.8039	18.4806	150

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.08411					
A	.01672	.00000				
P	-.09215	-.00000	.00240			
VAGL	-.19507	.00000	-.54241	.61535		
PA	.05965	-.00000	.82977	.03304	-.62774	
PA2	.04957	.00000	.82953	.09146	-.58086	.99809
NAGL	.08709	0	-.70563	.40580	.32551	-.47775
SL	-.21478	.00000	.13562	.60324	.60911	.19133
PS	-.01197	.00000	-.91310	.10764	.59506	-.94371

	PA2	NAGL	SL
NAGL	-.46533		
SL	.24059	-.26303	
PS	-.93864	.73986	-.24726

Table C-22. (Continued).

```
DEP. VAR... TIME

MEAN RESPONSE      5758.94000        STD. DEV.      171.69871

FINAL STEP.

MULTIPLE R      .2148 ANOVA           DF   SUM SQUARES  MEAN SQ.       F
R SQUARE        .0461 REGRESSION       1.   202626.587   .20E+06     7.157
STD DEV     168.2574 RESIDUAL       148. 4189959.873 28310.540 SIG. .008
ADJ R SQUARE  .0397 COEFF OF VARIABILITY       2.9PCT

VARIABLE          B        S.E. B         F      SIG.       BETA   ELASTICITY

SL            -38.825     14.512      7.157   .008      -.21478    -.01774
CONSTANT     5861.128     40.592 20848.513   .000

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.


COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE          B              95P C.I.

SL            -38.8254     -67.5038  -10.1469
CONSTANT        .5E+04       .5E+04    .5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


SL           210.61193

               SL
```

Table C-23. Final Regression Analysis Results for the Ellipse Target.

\- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5912.0891	274.6387	202
ORIENT	.5792	.4949	202
A	1.1999	.9709	202
P	.6766	.6309	202
VAGL	20.3858	22.1913	202
PA	.2994	.2079	202
PA2	1.0600	.8004	202
NAGL	.7030	1.3717	202
SL	1.4569	1.0754	202
PS	95.5142	14.1966	202

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	-.07908					
A	-.18051	-.18583				
P	-.30453	-.16072	.59777			
VAGL	-.25180	-.10709	.75662	.70494		
PA	-.22859	-.22533	.62280	.81350	.43028	
PA2	-.23953	-.20707	.48009	.81327	.34881	.98000
NAGL	.16171	-.11174	.22031	-.25563	-.40056	.26918
SL	-.30431	-.16286	.65117	.83673	.73471	.83826
PS	.12871	-.03733	.41270	-.20528	.34265	-.21795

	PA2	NAGL	SL
NAGL	.17172		
SL	.83481	-.17365	
PS	-.39597	.26702	-.20606

Table C-23. (Continued).

```
DEP. VAR... TIME

MEAN RESPONSE      5912.08911       STD. DEV.      274.63874

FINAL STEP.

MULTIPLE R     .3310 ANOVA          DF  SUM SQUARES  MEAN SQ.       F
R SQUARE       .1096 REGRESSION      2. 1661058.928   .83E+06    12.243
STD DEV    260.4563 RESIDUAL       199.   .1349E+08 67837.465 SIG. .000
ADJ R SQUARE  .1006 COEFF OF VARIABILITY     4.4PCT

VARIABLE          B        S.E. B         F      SIG.        BETA   ELASTICITY

P          -141.772     29.505    23.088  .000       -.32565    -.01623
ORIENT      -72.926     37.609     3.760  .054       -.13142    -.00714
CONSTANT   6050.256     36.725 27141.500     0

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.


COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE          B              95P C.I.

P                -.1E+03      -.1E+03   -83.5895
ORIENT          -72.9263      -.1E+03     1.2369
CONSTANT          .6E+04       .5E+04     .6E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


ORIENT    1414.43190
P          178.34365 870.53479

           ORIENT    P
```

Table C-24. Final Regression Analysis Results for the Triangle Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5819.9187	180.3713	209
ORIENT	.4976	.5012	209
A	1.8660	1.6186	209
P	1.0220	.9158	209
VAGL	16.3127	15.1260	209
PA	.4229	.3491	209
PA2	1.5384	1.2189	209
NAGL	1.0048	.9277	209
SL	.8498	1.2299	209
PS	69.4402	17.6280	209

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

ORIENT	.06980					
A	-.20305	.00553				
P	-.06587	.00535	.49691			
VAGL	-.16936	.00517	.92657	.64966		
PA	-.23461	.00581	.97029	.36806	.83286	
PA2	-.24214	.00605	.96488	.39040	.83495	.99831
NAGL	-.19596	.00519	.60688	.16059	.29871	.73762
SL	-.20701	.00331	.27085	-.24581	-.03028	.45829
PS	-.21070	.00883	.71669	.81536	.73489	.70796
	TIME	ORIENT	A	P	VAGL	PA

NAGL	.73874		
SL	.46862	.78780	
PS	.73779	.54612	.20686
	PA2	NAGL	SL

Table C-24. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5819.91866 STD. DEV. 180.37132

FINAL STEP.

MULTIPLE R	.2714	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.0737	REGRESSION	2.	498520.263	.24E+06	8.191
STD DEV	174.4410	RESIDUAL	206.	6268513.354	30429.676	SIG. .000
ADJ R SQUARE	.0647	COEFF OF VARIABILITY		3.0PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
PA2	-347.980	170.972	4.142	.043	-2.35146	-.09198
PA	1091.745	596.973	3.345	.069	2.11289	.07933
CONSTANT	5893.551	21.934	72200.067	.000		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
PA2	-.3E+03	-.6E+03	-10.8995
PA	.1E+04	-85.2152	.2E+04
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

PA	.356E+06	
PA2	-.101E+06	.292E+05
	PA	PA2

Table C-25. Final Regression Analysis Results for the Trapezoid Target.

\- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5877.0481	229.6170	208
ORIENT	.5048	.5012	208
A	1.4188	1.3156	208
P	1.0145	.9179	208
VAGL	16.1615	12.6108	208
PA	.4985	.4158	208
PA2	1.8830	1.5222	208
NAGL	.6827	1.3568	208
SL	.9088	1.2565	208
PS	87.0620	15.9387	208

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

ORIENT	.09886					
A	-.18613	.00748				
P	.00039	.00919	.05512			
VAGL	-.24072	.00590	.90059	.21714		
PA	-.25158	.01114	.91784	.22214	.93363	
PA2	-.25577	.01065	.90418	.25402	.94026	.99845
NAGL	-.00147	.02357	.25523	.53928	.18388	.36963
SL	-.16272	.01819	.20785	.53114	.44747	.51286
PS	-.18784	.00514	.77331	.57293	.87750	.91846
	TIME	ORIENT	A	P	VAGL	PA

NAGL	.35374		
SL	.52624	.68801	
PS	.83792	.25454	.40290
	PA2	NAGL	SL

Table C-25. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5877.04808 STD. DEV. 229.61698

FINAL STEP.

MULTIPLE R	.2558	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.0654	REGRESSION	1.	713991.782	.71E+06	14.420
STD DEV	222.5172	RESIDUAL	206.	.1019E+08	49513.921	SIG. .000
ADJ R SQUARE	.0609	COEFF OF VARIABILITY		3.8PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
PA2	-38.583	10.160	14.420	.000	-.25577	-.01236
CONSTANT	5949.697	24.578	58601.693	.000		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
PA2	-38.5826	-58.6142	-18.5510
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

PA2	103.23259
	PA2

Table C-26. Final Regression Analysis Results for the Square Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5865.8000	262.6052	180
ORIENT	.5000	.5014	180
A	2.3333	1.5457	180
P	1.1067	.8268	180
VAGL	35.8122	22.2213	180
PA	.3908	.3906	180
PA2	1.3466	1.4148	180
NAGL	.8333	1.4666	180
SL	.9433	1.2157	180
PS	114.0433	41.7121	180

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	-.01926					
A	-.18397	-.00000				
P	-.11980	-.00000	.43733			
VAGL	-.29432	-.00000	.54055	.70456		
PA	-.17171	.00000	.92149	.07385	.27679	
PA2	-.17432	.00000	.90362	.04329	.25568	.99918
NAGL	-.16674	0	-.14244	.51924	.53779	-.22592
SL	-.22133	.00000	-.09157	.45356	.78493	-.32701
PS	.42485	0	-.43984	-.08890	-.38645	-.50782

	PA2	NAGL	SL
NAGL	-.30676		
SL	-.33879	.69686	
PS	-.51791	-.11120	-.15486

Table C-26. (Continued).

```
DEP. VAR... TIME

MEAN RESPONSE      5865.80000       STD. DEV.     262.60516

FINAL STEP.

MULTIPLE R     .4531 ANOVA           DF  SUM SQUARES  MEAN SQ.       F
R SQUARE       .2053 REGRESSION      2.  2533995.275   .125+07     22.860
STD DEV     235.4237 RESIDUAL      177.  9810107.525 55424.336 SIG. .000
ADJ R SQUARE   .1963 COEFF OF VARIABILITY     4.0PCT

VARIABLE          B       S.E. B        F       SIG.       BETA   ELASTICITY

PS            2.519        .427    34.810       0        .40017    .04898
SL          -34.422      14.651     5.520    .020       -.15936   -.00554
CONSTANT   5610.960      55.487 10225.822       0

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.


COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE          B             95P C.I.

PS            2.5193        1.6766     3.3620
SL          -34.4224      -63.3352    -5.5096
CONSTANT      .5E+04        .5E+04     .5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


SL          214.64687
PS             .96878     .18233

               SL          PS
```

Table C-27. Final Regression Analysis Results for the Rectangle Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5882.0240	216.3262	208
ORIENT	.5000	.5012	208
A	1.1978	1.0971	208
P	.6638	.4769	208
VAGL	22.3507	17.5142	208
PA	.2957	.3137	208
PA2	1.0423	1.1895	208
NAGL	.7212	1.3933	208
SL	.8150	1.1765	208
PS	128.0246	49.2705	208

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.03429					
A	-.20208	-.00988				
P	-.19846	-.01142	.84737			
VAGL	-.34657	-.00578	.34460	.50396		
PA	-.24898	-.01296	.87945	.77975	.32584	
PA2	-.23854	-.01291	.86214	.75359	.28115	.99848
NAGL	-.18490	.00000	-.21135	.21179	.58127	-.07893
SL	-.24911	-.00115	-.22003	.03163	.83665	-.13653
PS	.42303	.01026	-.35117	-.22128	-.42292	-.56777

	PA2	NAGL	SL
NAGL	-.10111		
SL	-.17062	.71221	
PS	-.56862	-.20359	-.26534

Table C-27. (Continued).

```
DEP. VAR... TIME

MEAN RESPONSE      5882.02404       STD. DEV.      216.32619

FINAL STEP.

MULTIPLE R     .4617 ANOVA          DF   SUM SQUARES  MEAN SQ.       F
R SQUARE       .2132 REGRESSION      2.  2065131.052   .10E+07    27.772
STD DEV     192.8206 RESIDUAL      205. 7621851.828 37179.765 SIG. .000
ADJ R SQUARE  .2055 COEFF OF VARIABILITY      3.3PCT

VARIABLE          B       S.E. B        F      SIG.       BETA  ELASTICITY

PS            1.478        .300     24.251  .000       .33668    .03217
VAGL         -2.522        .844      8.919  .003      -.20418   -.00959
CONSTANT   5749.144     51.238 12590.069     0

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.


COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE          B              95P C.I.

PS             1.4782        .8864     2.0700
VAGL          -2.5219      -4.1868     -.8570
CONSTANT       .5E+04       .5E+04     .5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


VAGL           .71308
PS             .10720     .09010

            VAGL       PS
```

Table C-28. Final Regression Analysis Results for the Right Turn Arrow Target.

- - - REGRESSION - - - .

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5848.1649	252.7571	188
ORIENT	.4468	.4985	188
A	.7226	.5862	188
P	1.2584	1.5594	188
VAGL	21.7618	17.2980	188
PA	.3930	.3777	188
PA2	2.9930	3.0549	188
NAGL	3.8564	3.0931	188
SL	.6750	.8062	188
PS	28.7398	10.6851	188

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	-.00661					
A	-.29064	-.00090				
P	-.18624	.06841	.87311			
VAGL	-.36650	-.00244	.77802	.72124		
PA	-.25103	-.09829	.46710	-.01204	.24987	
PA2	-.23240	-.09595	.42791	-.05099	.19332	.99794
NAGL	-.34083	.00369	.63515	.47824	.78070	.49769
SL	-.18757	-.06320	.73153	.72875	.69666	.05332
PS	.09643	-.11150	.33774	.18597	-.12566	.30088

	PA2	NAGL	SL
NAGL	.47114		
SL	-.00104	.23744	
PS	.30435	-.13867	.43596

Table C-28. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5848.16489 STD. DEV. 252.75714

FINAL STEP.

MULTIPLE R	.4179	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.1746	REGRESSION	3.	2086198.352	.69E+06	12.976
STD DEV	231.4946	RESIDUAL	184.	9860515.536	53589.758	SIG. .000
ADJ R SQUARE	.1612	COEFF OF VARIABILITY		4.0PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
VAGL	-4.348	1.035	17.633	.000	-.29758	-.01618
PA	-143.061	49.332	8.410	.004	-.21379	-.00961
PS	2.918	1.702	2.939	.088	.12336	.01434
CONSTANT	5915.153	55.850	11217.221	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
VAGL	-4.3483	-6.3912	-2.3053
PA	-.1E+03	-.2E+03	-45.7317
PS	2.9181	-.4400	6.2761
CONSTANT	.5E+04	.5E+04	.6E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

VAGL	1.07224		
PA	-15.53248	2433.64972	
PS	.38332	-29.04360	2.89693
	VAGL	PA	PS

Table C-29. Final Regression Analysis Results for the Crescent Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5849.4067	244.8382	209
ORIENT	.5024	.5012	209
A	.7611	.9390	209
P	1.1799	1.4747	209
VAGL	16.7174	12.8755	209
PA	.7178	.5963	209
PA2	5.7586	4.6537	209
NAGL	6.6986	4.9381	209
SL	1.0115	.9868	209
PS	28.0336	12.3851	209

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.04166					
A	-.09002	.00955				
P	-.14466	.01080	.71763			
VAGL	-.28813	.00498	.60778	.70206		
PA	-.20131	.00540	.84856	.50750	.75854	
PA2	-.21129	.00530	.83311	.51097	.76744	.99996
NAGL	-.33279	.00321	.32241	.63454	.90582	.54146
SL	-.17691	.00724	.88913	.69115	.84830	.85807
PS	-.00572	.00565	.77509	.24622	.16502	.74369

	PA2	NAGL	SL
NAGL	.56726		
SL	.84505	.57080	
PS	.73212	-.06839	.49707

Table C-29. (Continued).

```
DEP. VAR... TIME

MEAN RESPONSE      5849.40670       STD. DEV.      244.83818

FINAL STEP.

MULTIPLE R      .3328 ANOVA             DF   SUM SQUARES  MEAN SQ.       F
R SQUARE        .1107 REGRESSION        1. 1380894.869    .13E+07    25.780
STD DEV     231.4397 RESIDUAL         207.    .1108E+08 53564.336 SIG. .000
ADJ R SQUARE   .1065 COEFF OF VARIABILITY      4.0PCT

VARIABLE          B        S.E. B         F       SIG.       BETA   ELASTICITY

NAGL         -16.500       3.250     25.780   .000       -.33279    -.01890
CONSTANT    5959.935      27.021  48648.087      0

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.


COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE          B              95P C.I.

NAGL          -16.5002     -22.9071  -10.0934
CONSTANT        .5E+04        .5E+04    .6E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


NAGL          10.56077

              NAGL
```

Table C-30. Final Regression Analysis Results for the Cross Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5793.4333	167.9265	180
ORIENT	.5000	.5014	180
A	.9783	.9994	180
P	1.7717	1.8902	180
VAGL	13.5292	8.1810	180
PA	.6724	.4551	180
PA2	5.2317	3.3733	180
NAGL	3.5000	3.4617	180
SL	.7717	.7317	180
PS	17.0175	5.4651	180

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	-.04512					
A	-.14238	.00000				
P	-.17472	.00000	.91541			
VAGL	-.16325	.00000	.13694	.08783		
PA	-.14116	.00000	.88250	.67155	.37470	
PA2	-.14739	.00000	.87186	.66735	.41157	.99880
NAGL	-.12061	0	-.47695	-.33438	.62174	-.28215
SL	-.17140	-.00000	.85217	.80522	.03095	.77584
PS	.00456	.00000	.75300	.65251	-.44346	.60181

	PA2	NAGL	SL
NAGL	-.24564		
SL	.76205	-.22730	
PS	.57668	-.85326	.58938

Table C-30. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5793.43333 STD. DEV. 167.92653

FINAL STEP.

MULTIPLE R	.2581	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.0666	REGRESSION	2.	336242.241	.16E+06	6.316
STD DEV	163.1511	RESIDUAL	177.	4711435.959	26618.282	SIG. .002
ADJ R SQUARE	.0561	COEFF OF VARIABILITY		2.8PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
P	-21.509	6.845	9.873	.002	-.24212	-.00658
NAGL	-9.778	3.738	6.843	.010	-.20157	-.00591
CONSTANT	5865.764	23.921	60129.867	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
P	-21.5093	-35.0182	-8.0004
NAGL	-9.7781	-17.1547	-2.4016
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

P	46.85805	
NAGL	8.55569	13.97162
	P	NAGL

Table C-31. Final Regression Analysis Results for the X Target.

\- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5803.2976	157.4649	205
ORIENT	.4341	.4969	205
A	.7178	.8830	205
P	1.7916	2.0446	205
VAGL	11.6883	15.3199	205
PA	.4195	.3015	205
PA2	3.2117	2.3663	205
NAGL	5.2537	4.6793	205
SL	.6441	.6636	205
PS	26.2660	5.1920	205

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.05166					
A	-.15670	-.11379				
P	-.20467	-.04405	.94660			
VAGL	-.19533	.08901	-.23968	-.10696		
PA	-.22672	-.12732	.48135	.56682	.28515	
PA2	-.22543	-.09615	.36438	.48292	.35165	.98901
NAGL	-.24896	-.02441	.04897	.22079	.79995	.73964
SL	-.18188	-.18664	.85800	.86199	-.13070	.75673
PS	.03601	-.14171	.59661	.50020	-.51226	.17944

	PA2	NAGL	SL
NAGL	.78555		
SL	.66705	.37538	
PS	.08724	-.23331	.55072

Table C-31. (Continued).

```
DEP. VAR... TIME

MEAN RESPONSE      5803.29756       STD. DEV.       157.46492

FINAL STEP.

MULTIPLE R     .2925 ANOVA           DF   SUM SQUARES  MEAN SQ.       F
R SQUARE       .0855 REGRESSION       2.   432672.361   .21E+06     9.448
STD DEV     151.3233 RESIDUAL       202. 4625548.488 22898.755 SIG. .000
ADJ R SQUARE  .0765 COEFF OF VARIABILITY       2.6PCT

VARIABLE         B         S.E. B         F       SIG.       BETA   ELASTICITY

NACL         -7.208        2.321       9.642   .002      -.21421    -.00653
P           -12.120        5.313       5.204   .024      -.15737    -.00374
CONSTANT   5862.882       17.314     .11E+06     0

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.


COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE         B             95P C.I.

NAGL          -7.2084     -11.7858    -2.6311
P            -12.1200     -22.5959    -1.6442
CONSTANT       .5E+04       .5E+04     .5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


P              28.22678
NAGL           -2.72307    5.38912

               P           NAGL
```

Table C-32. Final Regression Analysis Results for the E Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5789.4279	177.7008	201
ORIENT	.4776	.5007	201
A	1.5517	1.1125	201
P	3.6200	2.3602	201
VAGL	11.3365	15.0754	201
PA	.5203	.5274	201
PA2	3.9012	4.1174	201
NAGL	3.0348	3.4632	201
SL	1.1348	1.0081	201
PS	38.9304	12.9090	201

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.09940					
A	-.26011	.03126				
P	-.21459	.02983	.93655			
VAGL	-.18761	-.01808	.47822	.36185		
PA	-.26962	.03394	.87370	.66153	.47447	
PA2	-.26796	.03363	.85328	.63150	.47630	.99911
NAGL	-.18854	.01054	.55797	.43894	.69951	.58805
SL	-.26071	.01096	.89245	.75157	.76760	.83609
PS	.03004	.00981	-.34226	-.26200	.11543	-.28159

	PA2	NAGL	SL
NAGL	.59164		
SL	.82425	.73348	
PS	-.26360	.33207	-.28522

Table C-32. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5789.42786 STD. DEV. 177.70078

FINAL STEP.

MULTIPLE R	.2696	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.0727	REGRESSION	1.	459099.861	.45E+06	15.600
STD DEV	171.5494	RESIDUAL	199.	5856413.343	29429.213	SIG. .000
ADJ R SQUARE	.0680	COEFF OF VARIABILITY		3.0PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
PA	-90.838	22.999	15.600	.000	-.26962	-.00816
CONSTANT	5836.688	17.017	.11E+06	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
PA	-90.8384	-.1E+03	-45.4858
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

PA	528.94536
	PA

Table C-33. Final Regression Analysis Results for the F Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5813.1827	183.2760	208
ORIENT	.5000	.5012	208
A	.9430	.6843	208
P	1.3959	1.2921	208
VAGL	11.6505	15.3922	208
PA	.5684	.5685	208
PA2	4.1817	4.3606	208
NAGL	3.0096	2.7958	208
SL	1.1267	1.0096	208
PS	27.4372	10.5413	208

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.03939					
A	-.15916	-.00528				
P	-.03207	.00653	.57477			
VAGL	-.16415	-.00374	.30851	-.24086		
PA	-.15642	-.00963	.87355	.12144	.48211	
PA2	-.15033	-.00953	.85642	.09794	.47784	.99881
NAGL	-.17762	.00000	.75219	.22461	.46509	.75990
SL	-.21332	-.00835	.75496	.01599	.77125	.85669
PS	.05841	.01651	-.08768	.42924	-.03653	-.28338

	PA2	NAGL	SL
NAGL	.75108		
SL	.84092	.80061	
PS	-.26908	.05953	-.32457

Table C-33. (Continued).

```
DEP. VAR... TIME

MEAN RESPONSE      5813.18269       STD. DEV.      183.27603

FINAL STEP.

MULTIPLE R      .2133 ANOVA             DF  SUM SQUARES  MEAN SQ.       F
R SQUARE        .0455 REGRESSION        1.  316420.605   .31E+06    9.821
STD DEV      179.4913 RESIDUAL        206. 6636730.453 32217.138 SIG. .002
ADJ R SQUARE    .0409 COEFF OF VARIABILITY      3.1PCT

VARIABLE          B         S.E. B        F      SIG.       BETA   ELASTICITY

SL           -38.724      12.357     9.821   .002      -.21332   -.00751
CONSTANT    5856.813      18.674  98369.489  .000

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.


COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE          B              95P C.I.

SL            -38.7244     -63.0858  -14.3630
CONSTANT        .5E+04       .5E+04    .5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


SL          152.68322

              SL
```

Table C-34. Final Regression Analysis Results for the Curve I Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5907.9617	214.3062	209
ORIENT	.5024	.5012	209
A	.3317	.3230	209
P	3.5828	3.8217	209
VAGL	2.5884	2.4302	209
PA	.6984	.9130	209
PA2	4.6072	6.5377	209
NAGL	10.3493	12.2975	209
SL	.7761	.8396	209
PS	93.6620	9.4222	209

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	-.03840					
A	-.17354	.00354				
P	-.21651	.00868	.52359			
VAGL	.00406	.00149	.66567	.05650		
PA	-.19637	.00913	.34801	.97971	-.08857	
PA2	-.18718	.00951	.33584	.97269	-.09997	.99806
NAGL	-.21098	.00649	.32967	.94934	-.15008	.95615
SL	-.26826	.00128	.49175	.12492	.57035	.02892
PS	.20713	-.00362	-.03051	-.57631	.57221	-.62659

	PA2	NAGL	SL
NAGL	.93842		
SL	.01074	-.01418	
PS	-.62656	-.65469	.11258

Table C-34. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5907.96172 STD. DEV. 214.30623

FINAL STEP.

MULTIPLE R	.3592	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.1290	REGRESSION	2.	1232458.298	.61E+06	15.257
STD DEV	200.9733	RESIDUAL	206.	8320391.395	40390.249	SIG. .000
ADJ R SQUARE	.1206	COEFF OF VARIABILITY		3.4PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
SL	-75.381	16.703	20.366	.000	-.29532	-.00990
PS	5.467	1.488	13.493	.000	.24038	.08668
CONSTANT	5454.372	139.244	1534.389	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
SL	-75.3808	-.1E+03	-42.4493
PS	5.4674	2.5330	8.4019
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

SL	279.00378	
PS	-2.79897	2.21538
	SL	PS

Table C-35. Final Regression Analysis Results for the Curve II Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5949.8835	295.2322	206
ORIENT	.4903	.5011	206
A	.2238	.2187	206
P	3.7611	4.8829	206
VAGL	4.2113	3.8924	206
PA	.7021	1.0494	206
PA2	4.6407	7.1892	206
NAGL	7.7427	10.6751	206
SL	.8373	.8827	206
PS	92.4596	10.8696	206

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.11566					
A	-.00140	-.00233				
P	-.21647	-.00725	-.23737			
VAGL	-.08305	-.00461	.22138	.58847		
PA	-.21581	-.00607	-.29620	.99570	.58538	
PA2	-.21751	-.00510	-.28925	.99137	.58091	.99845
NAGL	-.20291	-.01096	-.33072	.96713	.52370	.95539
SL	-.24133	-.00976	.77394	.01886	.32284	-.01185
PS	.28585	.00739	.48337	-.26435	.37711	-.29421

	PA2	NAGL	SL
NAGL	.93793		
SL	.00235	-.09532	
PS	-.30459	-.26946	-.03177

Table C-35. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5949.88350 STD. DEV. 295.23216

FINAL STEP.

MULTIPLE R	.4151	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.1723	REGRESSION	4.	3078679.800	.76E+06	10.460
STD DEV	271.2559	RESIDUAL	201.	.1478E+08	73579.778	SIG. .000
ADJ R SQUARE	.1558	COEFF OF VARIABILITY		4.6PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
PS	6.338	1.813	12.220	.001	.23336	.09850
SL	-83.054	21.600	14.785	.000	-.24833	-.01169
NAGL	-4.494	1.854	5.877	.016	-.16250	-.00595
ORIENT	64.644	37.811	2.923	.089	.10973	.00533
CONSTANT	5436.472	176.250	951.426	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
PS	6.3385	2.7632	9.9138
SL	-83.0538	-.1E+03	-40.4622
NAGL	-4.4940	-8.1494	-.8386
ORIENT	64.6443	-9.9118	139.2005
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

ORIENT	1429.63505			
NAGL	.72890	3.43663		
SL	8.65804	4.32560	466.55752	
PS	-.27187	.92038	2.34551	3.28763
	ORIENT	NAGL	SL	PS

Table C-36. Final Regression Analysis Results for the Angle I Target.

\- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5893.3317	201.3414	208
ORIENT	.5000	.5012	208
A	.3683	.3491	208
P	3.6409	4.6164	208
VAGL	3.5216	3.7659	208
PA	.7478	1.0700	208
PA2	4.8612	7.2738	208
NAGL	7.9087	10.7979	208
SL	.9610	.9034	208
PS	93.4814	9.7146	208

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	-.07001					
A	-.09153	.00525				
P	-.29306	-.00077	.41208			
VAGL	-.05035	.00733	.61778	-.25237		
PA	-.29671	-.00097	.31916	.99402	-.33392	
PA2	-.28904	-.00065	.32502	.99082	-.34962	.99829
NAGL	-.30156	-.00223	.26286	.95853	-.27660	.95741
SL	-.36484	.00064	-.03068	.26806	.30706	.28264
PS	.20594	-.00438	.14411	-.39389	.04259	-.40630

	PA2	NAGL	SL
NAGL	.93937		
SL	.25278	.36154	
PS	-.35686	-.59689	-.47758

Table C-36. (Continued).

```
DEP. VAR... TIME

MEAN RESPONSE      5893.33173      STD. DEV.      201.34137

FINAL STEP.

MULTIPLE R      .4177 ANOVA            DF  SUM SQUARES   MEAN SQ.        F
R SQUARE        .1745 REGRESSION       2.  1464227.345   .73E+06     21.666
STD DEV     183.8240 RESIDUAL        205.  6927210.766 33791.272 SIG. .000
ADJ R SQUARE   .1664 COEFF OF VARIABILITY      3.1PCT

VARIABLE          B        S.E. B        F       SIG.       BETA    ELASTICITY

SL           -69.469     14.618     22.585   .000      -.31169    -.01133
PA2           -5.820      1.815     10.276   .002      -.21025    -.00490
CONSTANT    5988.380     19.365  95629.592      0

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.


COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE          B               95P C.I.

SL            -69.4689     -98.2895   -40.6483
PA2            -5.8198      -9.3993    -2.2404
CONSTANT        .5E+04       .5E+04      .6E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.


PA2           3.29598
SL           -6.70827 213.68137

              PA2       SL
```

Table C-37. Final Regression Analysis Results for the Angle II Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5875.2367	226.4898	207
ORIENT	.4928	.5012	207
A	.4896	.3720	207
P	4.5260	5.2836	207
VAGL	4.2463	3.8746	207
PA	.7165	1.0509	207
PA2	4.7352	7.1978	207
NAGL	8.2512	11.1988	207
SL	.9753	.9034	207
PS	132.0596	9.3111	207

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	-.01053					
A	.05677	-.00119				
P	-.08272	.00969	.11743			
VAGL	.09731	.00458	.64421	.64992		
PA	-.07906	.00958	-.01746	.98975	.58486	
PA2	-.07902	.00935	-.04004	.98343	.58046	.99842
NAGL	-.07622	.00984	.05542	.96771	.53363	.95915
SL	-.24847	.00432	.45242	.34387	.06573	.25289
PS	.15552	-.00908	.45285	-.68242	.07469	-.72796

	PA2	NAGL	SL
NAGL	.94229		
SL	.23034	.35360	
PS	-.71341	-.79772	-.29219

Table C-37. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5875.23671 STD. DEV. 226.48984

FINAL STEP.

MULTIPLE R	.3126	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.0977	REGRESSION	2.	1022701.817	.51E+06	11.048
STD DEV	216.1904	RESIDUAL	204.	9534613.584	46738.302	SIG. .000
ADJ R SQUARE	.0889	COEFF OF VARIABILITY		3.7PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
SL	-86.422	18.696	21.367	.000	-.34471	-.01435
A	129.518	45.405	8.137	.005	.21272	.01079
CONSTANT	5896.113	26.185	50703.486	.000		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
SL	-86.4216	-.1E+03	-49.5591
A	129.5184	39.9945	219.0422
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

A	2061.64237	
SL	-384.06026	349.54672
	A	SL

Table C-38. Final Regression Analysis Results for the Block I Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5933.0874	358.8627	206
ORIENT	.4951	.5012	206
A	.2803	.2356	206
P	7.2879	5.7545	206
VAGL	3.5558	3.7680	206
PA	1.5874	1.2078	206
PA2	11.3482	8.3510	206
NAGL	14.1796	11.0207	206
SL	.6887	.4501	206
PS	76.5942	11.2319	206

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.06360					
A	-.26478	-.00412				
P	-.38116	-.00712	.75824			
VAGL	-.19724	-.00685	.10819	.65687		
PA	-.37326	-.00771	.81221	.99230	.59356	
PA2	-.36087	-.00783	.82057	.98810	.60217	.99851
NAGL	-.37870	-.00911	.84231	.96351	.56154	.97871
SL	-.27220	-.00803	.77314	.92132	.65426	.94218
PS	-.08060	-.00010	.76741	.64919	.36888	.69308

	PA2	NAGL	SL
NAGL	.98084		
SL	.95775	.92218	
PS	.72472	.66842	.84901

Table C-38. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5933.08738 STD. DEV. 358.86275

FINAL STEP.

MULTIPLE R	.4398	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.1934	REGRESSION	2.	5105763.718	.25E+07	24.336
STD DEV	323.8823	RESIDUAL	203.	.2129E+08	.10E+06	SIG. .000
ADJ R SQUARE	.1855	COEFF OF VARIABILITY		5.5PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
P	-35.445	5.168	47.038	0	-.56838	-.04354
PS	9.214	2.648	12.110	.001	.28839	.11895
CONSTANT	5485.658	182.045	908.029	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
P	-35.4449	-45.6349	-25.2549
PS	9.2141	3.9934	14.4348
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

P	26.70910	
PS	-8.88357	7.01084
	P	PS

Table C-39. Final Regression Analysis Results for the Block II Target.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5953.5121	349.1460	207
ORIENT	.4300	.4963	207
A	.2221	.2180	207
P	5.9489	4.6534	207
VAGL	2.5742	2.4160	207
PA	1.2220	.9049	207
PA2	8.0690	5.6582	207
NAGL	16.9758	13.4938	207
SL	.6794	.6643	207
PS	71.0682	4.9466	207

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.03352					
A	-.18289	.14452				
P	-.36637	.18132	.66852			
VAGL	-.04639	.15112	.31936	.69830		
PA	-.33820	.19154	.66947	.98802	.65031	
PA2	-.28870	.20227	.68062	.97591	.66508	.99488
NAGL	-.38939	.17844	.67359	.95992	.49070	.97425
SL	-.13146	.14507	.83142	.70156	.66472	.68741
PS	-.00367	.28550	.61774	.32597	-.02490	.38424

	PA2	NAGL	SL
NAGL	.96418		
SL	.69089	.57192	
PS	.40995	.42220	.39736

Table C-39. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5953.51208 STD. DEV. 349.14604

FINAL STEP.

MULTIPLE R	.6039	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.3647	REGRESSION	3.	9157858.057	.30E+07	38.841
STD DEV	280.3424	RESIDUAL	203.	.1595E+08	78591.880	SIG. 0
ADJ R SQUARE	.3553	COEFF OF VARIABILITY		4.7PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
NAGL	-19.359	6.586	8.641	.004	-.74818	-.05520
PA2	265.466	35.031	57.426	0	4.30212	.35979
PA	-1500.717	257.707	33.911	0	-3.88937	-.30802
CONSTANT	5973.930	36.496	26792.786	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
NAGL	-19.3589	-32.3439	-6.3739
PA2	265.4660	196.3945	334.5376
PA	-.1E+04	-.2E+04	-.9E+03
CONSTANT	.5E+04	.5E+04	.6E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

PA	.664E+05		
PA2	-.838E+04	1227.17951	
NAGL	-950.12821	51.44247	43.37055
	PA	PA2	NAGL

Table C-40. Final Regression Analysis Results for the Geometric Shapes.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5856.6785	231.2815	1157
ORIENT	.5143	.5000	1157
A	1.6071	1.3520	1157
P	.9104	.7728	1157
VAGL	22.7152	19.8181	1157
PA	.3932	.3560	1157
PA2	1.4083	1.3061	1157
NAGL	1.1789	1.5969	1157
SL	1.2058	1.3042	1157
PS	98.5681	35.4547	1157

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.02863					
A	-.18518	-.03065				
P	-.13967	-.02875	.41285			
VAGL	-.24661	-.02372	.51632	.51969		
PA	-.20188	-.02819	.84250	.33306	.28135	
PA2	-.20244	-.02754	.81046	.34588	.25583	.99613
NAGL	-.15062	-.02107	.11015	.24160	.22544	.14247
SL	-.25076	-.01725	.12344	.28580	.51951	.21853
PS	.19868	-.00104	-.07499	.02975	.10553	-.23013

	PA2	NAGL	SL
NAGL	.11476		
SL	.21031	.60689	
PS	-.25187	.00014	-.06367

Table C-40. (Continued).

FINAL STEP.

MULTIPLE R	.3612	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.1304	REGRESSION	4.	8065472.686	.20E+07	43.200
STD DEV	216.0453	RESIDUAL	1152.	.5377E+08	46675.567	SIG. .000
ADJ R SQUARE	.1274	COEFF OF VARIABILITY		3.7PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
SL	-22.816	5.768	15.650	.000	-.12866	-.00470
PS	1.231	.190	42.106	.000	.18865	.02071
VAGL	-2.085	.390	28.536	.000	-.17866	-.00809
PA2	-14.548	5.267	7.630	.006	-.08216	-.00350
CONSTANT	5830.739	22.618	66459.008	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
SL	-22.8164	-34.1324	-11.5004
PS	1.2306	.8585	1.6027
VAGL	-2.0850	-2.8507	-1.3192
PA2	-14.5483	-24.8819	-4.2146
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

VAGL	.15233			
PA2	-.46235	27.73932		
SL	-1.13276	-1.70705	33.26415	
PS	-.01593	.28067	.12888	.03597
	VAGL	PA2	SL	PS

Table C-41. Final Regression Analysis Results for the Symbol Shapes.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5816.3661	201.8525	1191
ORIENT	.4769	.4997	1191
A	.9456	.9308	1191
P	1.8365	1.9859	1191
VAGL	14.3732	14.8155	1191
PA	.5489	.4985	1191
PA2	4.2152	3.8835	1191
NAGL	4.2552	4.0684	1191
SL	.8998	.9048	1191
PS	27.9108	11.8439	1191

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.02971					
A	-.18296	-.00670				
P	-.17714	.00714	.85461			
VAGL	-.20567	.00964	.25416	.16065		
PA	-.19154	-.00766	.71045	.36569	.40822	
PA2	-.18892	-.00446	.67391	.33483	.41374	.99747
NAGL	-.20790	-.00330	.16054	.17697	.66421	.45375
SL	-.19314	-.02162	.80124	.58778	.51813	.72638
PS	.02981	-.02601	.28711	.26608	-.04861	.09619

	PA2	NAGL	SL
NAGL	.47920		
SL	.69546	.39412	
PS	.08946	-.06760	.16631

Table C-41. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5816.36608 STD. DEV. 201.85254

FINAL STEP.

MULTIPLE R	.2713	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.0736	REGRESSION	4.	3569388.638	.89E+06	23.562
STD DEV	194.6080	RESIDUAL	1186.	.4491E+08	37872.263	SIG. .000
ADJ R SQUARE	.0705	COEFF OF VARIABILITY		3.3PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
NAGL	-6.248	1.857	11.321	.001	-.12594	-.00457
A	-34.967	6.591	28.145	.000	-.16125	-.00568
PS	1.087	.502	4.690	.031	.06381	.00522
VAGL	-1.062	.521	4.152	.042	-.07794	-.00262
CONSTANT	5860.931	16.114	.13E+06	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
NAGL	-6.2483	-9.8917	-2.6049
A	-34.9671	-47.8986	-22.0357
PS	1.0874	.1023	2.0726
VAGL	-1.0619	-2.0844	-.0394
CONSTANT	.5E+04	.5E+04	.5E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

A	43.44224			
VAGL	-.72602	.27160		
NAGL	-.04132	-.62667	3.44855	
PS	-1.02535	.01835	.04290	.25212
	A	VAGL	NAGL	PS

Table C-42. Final Regression Analysis Results for the Nonsense Shapes.

- - - REGRESSION - - -

VARIABLE	MEAN	STANDARD DEV	CASES
TIME	5918.7611	282.2372	1243
ORIENT	.4851	.5000	1243
A	.3195	.3070	1243
P	4.7872	5.0530	1243
VAGL	3.4476	3.4803	1243
PA	.9448	1.0902	1243
PA2	6.3702	7.5072	1243
NAGL	10.8978	12.1213	1243
SL	.8198	.7991	1243
PS	93.2357	21.6460	1243

CORRELATION COEFFICIENTS.

A VALUE OF 99.00000 IS PRINTED
IF A COEFFICIENT CANNOT BE COMPUTED.

	TIME	ORIENT	A	P	VAGL	PA
ORIENT	.02261					
A	-.12607	.02478				
P	-.24916	.02208	.29615			
VAGL	-.06466	.02189	.44409	.39426		
PA	-.23027	.02061	.21316	.98611	.30505	
PA2	-.21281	.02035	.20583	.97717	.29807	.99701
NAGL	-.24315	.02120	.21885	.93408	.23167	.93713
SL	-.23480	.02226	.45823	.29301	.35936	.24154
PS	-.02735	.03104	.38293	-.17358	.21241	-.24469

	PA2	NAGL	SL
NAGL	.91756		
SL	.22412	.23288	
PS	-.24666	-.27503	.10432

Table C-42. (Continued).

DEP. VAR... TIME

MEAN RESPONSE 5918.76106 STD. DEV. 282.23721

FINAL STEP.

MULTIPLE R	.3628	ANOVA	DF	SUM SQUARES	MEAN SQ.	F
R SQUARE	.1316	REGRESSION	6.	.1302E+08	.21E+07	31.229
STD DEV	263.6424	RESIDUAL	1236.	.8591E+08	69507.301	SIG. .000
ADJ R SQUARE	.1274	COEFF OF VARIABILITY		4.5PCT		

VARIABLE	B	S.E. B	F	SIG.	BETA	ELASTICITY
P	-23.575	13.037	3.270	.071	-.42207	-.01907
SL	-55.812	10.477	28.378	.000	-.15802	-.00773
PA2	106.717	18.931	31.778	.000	2.83856	.11486
PA	-750.565	175.515	18.287	.000	-2.89908	-.11981
VAGL	10.908	3.012	13.113	.000	.13451	.00635
NAGL	6.263	2.358	7.057	.008	.26899	.01153
CONSTANT	6000.847	12.789	.22E+06	0		

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION.

COEFFICIENTS AND CONFIDENCE INTERVALS.

VARIABLE	B	95P C.I.	
P	-23.5748	-49.1515	2.0019
SL	-55.8119	-76.3666	-35.2572
PA2	106.7171	69.5771	143.8572
PA	-.7E+03	-.1E+04	-.4E+03
VAGL	10.9084	4.9984	16.8184
NAGL	6.2632	1.6378	10.8886
CONSTANT	.6E+04	.5E+04	.6E+04

VARIANCE/COVARIANCE MATRIX OF THE UNNORMALIZED REGRESSION COEFFICIENTS.

P	169.95801					
VAGL	-22.91586	9.07449				
PA	-.142E+04	123.84273	.308E+05			
PA2	98.23772	-6.12521	-.318E+04	358.37556		
NAGL	-.28968	1.43524	-239.08908	26.32477	5.55839	
SL	-15.89200	-4.72482	-161.49072	28.88509	2.01313	109.76822
	P	VAGL	PA	PA2	NAGL	SL

Table C-43. Regression Analysis Results for Left-Oriented Targets.

```
DEP. VAR... TIME

MEAN RESPONSE      5943.37288        STD. DEV.      358.01060

VARIABLE ORIENT   IS A CONSTANT   INCLUSION LEVEL SET TO ZERO.

FINAL STEP.

MULTIPLE R     .5879 ANOVA           DF   SUM SQUARES  MEAN SQ.       F
R SQUARE       .3457 REGRESSION       3. 5183715.170   .17E+07    20.075
STD DEV    293.3826 RESIDUAL       114. 9812360.423 86073.337 SIG. .000
ADJ R SQUARE  .3285 COEFF OF VARIABILITY      4.9PCT

VARIABLE          B         S.E. B        F       SIG.       BETA    ELASTICITY

NAGL         -21.701       9.744      4.960  .028      -.83906    -.05437
PA2          296.829      50.338     34.771  .000      4.92340     .35347
PA         -1653.074     376.546     19.273  .000     -4.33920    -.29811
CONSTANT    5937.475      44.228  18022.012     0
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Table C-44. Regression Analysis Results for Right-Oriented Targets.

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DEP. VAR... TIME

MEAN RESPONSE      5966.95506        STD. DEV.      338.57522

VARIABLE ORIENT   IS A CONSTANT.  INCLUSION LEVEL SET TO ZERO.

FINAL STEP.

MULTIPLE R     .6465 ANOVA           DF   SUM SQUARES  MEAN SQ.       F
R SQUARE       .4180 REGRESSION       3. 4216818.738   .14E+07    20.351
STD DEV    262.8106 RESIDUAL        85. 5870901.062 69069.424 SIG.      0
ADJ R SQUARE  .3975 COEFF OF VARIABILITY      4.4PCT

VARIABLE          B         S.E. B        F       SIG.       BETA    ELASTICITY

NAGL         -16.505       8.738      3.568  .062      -.61256    -.05461
PA2          205.893      50.196     16.825  .000      3.04039     .32379
PA         -1210.430     354.119     11.684  .001     -2.93120    -.28827
CONSTANT    6080.857      67.854   8031.205     0
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REFERENCES

1. Attneave, Fred, "Transfer of Experience with a Class-Schema to Identification-Learning of Patterns and Shapes", Journal of Experimental Psychology, 1957, 54, 81-88.

2. Attneave, Fred and Arnoult, Malcolm, D. "The Quantitative Study of Shape and Pattern Perception", Psychological Bulletin, 1956, 53, 452-471.

3. Bitterman, M.E., Krauskopf, John, and Hochberg, J.E., "Threshold for Visual Form: A Diffusion Model", American Journal of Psychology, 1954, 67, 205-219.

4. Casperson, Roland Carl, "The Visual Discrimination of Geometric Forms", Journal of Experimental Psychology, 1950, 40, 668-681.

5. Day, R. H., "The Physiological Basis of Form Perception in the Peripheral Retina", Psychological Review, 1957, 64, 38-48.

6. Deutsch, J.A., "A Theory of Shape Recognition", British Journal of Psychology, 1955, 46, 30-37.

7. Dodwell, P.C., "Coding and Learning in Shape Discrimination", Psychological Review, 1961, 68, 373-382.

8. Draper, N.R. and Smith, H., Applied Regression Analysis (New York: John Wiley and Sons, Inc., 1966).

9. Form Discrimination as Related to Military Problems, Joseph W. Wulfeck and John H. Taylor, Eds., NAS NRC Publication No. 561, National Academy of Science-National Research Council, Washington, D.C., 1957.

10. Graham, C.H., "Visual Form Perception" in Vision and Perception; C.H. Graham, Ed.; Wiley and Sons, Inc., New York; 1965.

11. Hake, Harold W., "Contributions of Psychology to the Study of Pattern Vision", WADC Technical Report 57-621, Astia Document No. AD142035. Wright Air Development Center, October 1957, pp. 60-79 and 99-118.

12. Helson, Harry and Fehrer, Elizabeth V., "The Role of Form in Perception", American Journal of Psychology, 1932, 44, 79-102.

13. Human Engineering Guide to Equipment Design, Harold P. Van Cott and Robert G. Kinkade, Eds., (McGraw Hill Publishing Co.) American Institute for Research, Washington, D.C., 1972.

14. Kaswan, Jacques and Young, Stephen, "The Effect of Luminance, Exposure Duration, and Task Complexity on Reaction Time", Journal of Experimental Psychology, 1965, 69, 393.

15. LeGrand, Yves, Form and Space Vision, Indiana University Press, Bloomington, Ill., 1967.

16. Nie, N.H. and Others., SPSS: Statistical Package for the Social Sciences, 2nd ed., (New York: McGraw-Hill, 1975).

17. Richards, Robert R., "An Investigation of the Effects of Target Size, Target Location Certainty, Distracting Images, and Information Content on Choice-Reaction Time, with Particular Attention to Application in Pre-determined Motion-Time Systems", An unpublished thesis from the Department of Industrial and Systems Engineering, Georgia Institute of Technology, 1976.

18. Sleight, Robert B., "The Relative Discriminability of Several Geometric Forms", Journal of Experimental Psychology, 1952, 43, 324-328.

19. Smith, Sidney L. and Thomas, Donald W., "Color versus Shape Coding in Information Displays", Journal of Applied Psychology, 1964, 48, 137-146.

20. Zusne, Leonard, Visual Perception of Form, Academic Press, New York, 1970.